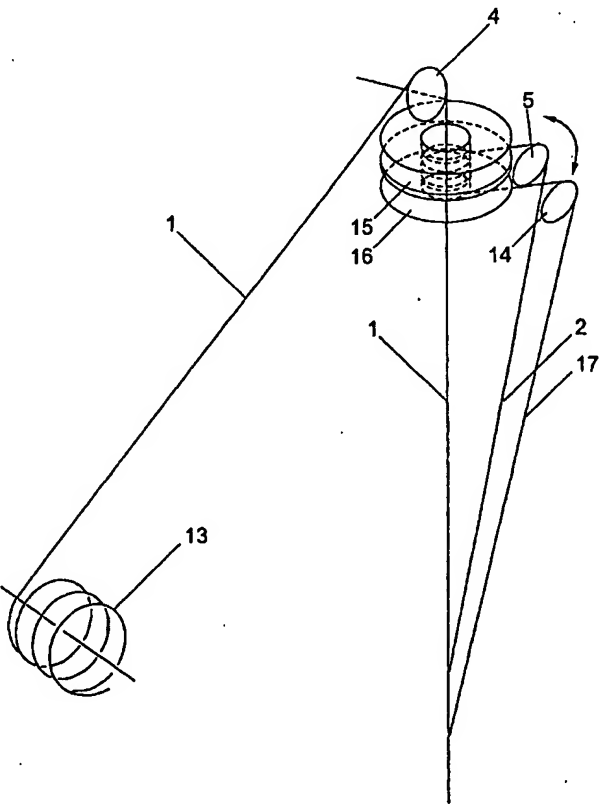




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>7</sup> : <b>B66C 13/14</b>	<b>A1</b>	(11) International Publication Number: <b>WO 00/56654</b> (43) International Publication Date: 28 September 2000 (28.09.00)
<p>(21) International Application Number: PCT/GB00/00978</p> <p>(22) International Filing Date: 22 March 2000 (22.03.00)</p> <p>(30) Priority Data:              09/274,259           22 March 1999 (22.03.99)      US              9923447.8           5 October 1999 (05.10.99)      GB</p> <p>(71) Applicant (for all designated States except US): DEEP TEK LIMITED [GB/GB]; Kilburns House, Newport-on-Tay, Fife DD6 8PL (GB).</p> <p>(72) Inventor; and          (75) Inventor/Applicant (for US only): CRAWFORD, Alec [GB/GB]; Kilburns House, Newport-on-Tay, Fife DD6 8PL (GB).</p> <p>(74) Agent: MURGITROYD &amp; COMPANY; 373 Scotland Street, Glasgow G5 8QA (GB).</p>	<p>(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b>          With international search report.          Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</p>	
<p>(54) Title: APPARATUS AND METHOD FOR USE IN HANDLING A LOAD</p> <p>(57) Abstract</p> <p>Apparatus and a method for use in handling a load is described. The apparatus includes a load-bearing rope (1, 19), and a mechanism for paying out and recovering the rope (1, 19). There is also a drum (3, 12, 15, 16) for holding a service cable (2, 17) with a length of the service cable (2, 17) extending from the drum (3, 12, 15, 16). A wrapping device rotates the length of service cable (2, 17) around the rope (1, 19) as the rope (1, 19) is payed out to wrap the service cable (2, 17) around the rope (1, 19), and to unwrap the service cable (2, 17) from the rope (1, 19) as the rope is recovered.</p> 		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakhstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

1     "Apparatus and Method for Use in Handling a Load"

2

3     This invention relates to apparatus for use in handling  
4     a load which is capable of raising and lowering, or of  
5     towing, a load and also handling service cables and/or  
6     hoses connected to the load. The invention is  
7     particularly, but not exclusively, applicable to the  
8     handling of subsea equipment such as grabs.

9

10    Hitherto, providing services to underwater equipment  
11    has required the provision of a specific bundle of  
12    cable(s) and/or hose(s) dedicated to each application.  
13    For some applications, it is known to incorporate the  
14    service bundle within an armoured hoist rope. This  
15    approach has a number of deficiencies. The resulting  
16    rope is costly, gives inferior hoisting properties, and  
17    by virtue of limitations on the diameter of rope which  
18    can be handled the services which can be incorporated  
19    are limited. Further, in practice it is impossible  
20    with this arrangement to add to the length of the rope  
21    or to join different types of materials, for example  
22    wire ropes with fibre ropes.

1 It is also known from our previous application  
2 PCT/GB96/00158 to wrap service cable around a rope  
3 being paid out, and to unwrap the service cable from  
4 the rope as the rope is recovered.

5  
6 According to the present invention there is provided  
7 apparatus for use in handling a load comprising a load-  
8 bearing rope, a mechanism for paying out and recovering  
9 the rope, a first service cable holder for holding a  
10 first service cable with a length of the first service  
11 cable extending therefrom, a second service cable  
12 holder for holding a second service cable with a length  
13 of the second service cable extending therefrom, and a  
14 wrapping device for rotating said lengths of service  
15 cable around the rope as the rope is payed out to wrap  
16 the service cables around the rope, wherein one of the  
17 first and second service cables is wrapped over the  
18 other.

19  
20 The service cable holders can be drums.

21  
22 Typically the wrapping device can recover the service  
23 cables to their respective drums during recovery of the  
24 rope and cables.

25  
26 The term "service cable" is used herein to denote a  
27 flexible elongate member used for conveying power or  
28 data, such as an electrical cable, a fibre optic cable,  
29 or a pneumatic or hydraulic hose.

30  
31 Preferably, the service cables is wrapped helically  
32 around the rope.

1 Typically, the load-bearing rope will be a hoist rope  
2 used for raising and lowering a load. Alternatively,  
3 the load-bearing rope may be a towing rope used for  
4 paying out, towing and recovering a load such as a  
5 marine sensor array.

6  
7 Preferably, the mechanism for paying out and recovering  
8 the rope comprises a rope winch, from which the rope  
9 passes over a rope sheave and thereafter extends to the  
10 load along a substantially straight axis.

11  
12 The wrapping device may comprise the or each service  
13 cable drum being arranged for rotation about a drum  
14 axis which coincides with said axis, the drum typically  
15 having a central aperture through which the load-  
16 bearing rope passes, said length of service cable  
17 preferably passing over a service cable sheave which is  
18 mounted for movement in a circular path around said  
19 axis.

20  
21 Alternatively, the or each service cable drum may be  
22 rotatable on a structural member which is arranged for  
23 movement in a circular path about said axis.

24  
25 The hoist rope winch, the or each service cable drum,  
26 and the wrapping device may conveniently each have a  
27 respective driving motor; they could however be driven  
28 by a single source through appropriate mechanical  
29 linkages.

30  
31 The first and second cables are typically wrapped  
32 around the rope in different directions; for example,

1 the first cable can be wrapped onto the rope in an  
2 anticlockwise direction and the second cable can be  
3 wrapped around the rope in a clockwise direction so  
4 that one cable overlays the other. This option is to  
5 be preferred but the invention can also work well with  
6 the service cables being wrapped in the same direction  
7 but at different pitches of helix, so that one  
8 overwraps the other.

9  
10 The invention also provides apparatus for use in  
11 handling a load comprises a load-bearing rope, a  
12 mechanism for paying out and recovering the rope, a  
13 mechanism for holding and paying out a service cable,  
14 and a wrapping device for rotating one of the service  
15 cable and the rope around the other as they are payed  
16 out to wrap the said one of the service cable and the  
17 rope around the other, and to unwrap one of the service  
18 cable and the rope from the other as it is recovered,  
19 wherein at least part of the wrapping device can be  
20 moved to accommodate large objects.

21  
22 In a preferred embodiment the service cable is provided  
23 on drum which is mounted on an arm which rotates around  
24 the axis of the rope. The drum can be arranged to  
25 rotate about a horizontal or a vertical axis.

26  
27 The service cable holder is preferably mounted on an  
28 arm that is preferably hinged to a frame and can be  
29 provided with a lifting mechanism such as a hydraulic  
30 ram to lift the arm with respect to the frame. Instead  
31 of a hydraulic ram the lifting mechanism may be a

1 screw-driven mechanism which can be electrically or  
2 hydraulically powered.

3

4 The invention also provides apparatus for use in  
5 handling a load comprising a load-bearing rope, a  
6 mechanism for paying out and recovering the rope, a  
7 drum for holding a service cable with a length of the  
8 service cable extending therefrom, and a wrapping  
9 device for rotating said length of service cable around  
10 the rope as the rope is payed out to wrap the service  
11 cable around the rope, and to unwrap the service cable  
12 from the rope as the rope is recovered, wherein the  
13 wrapping device rotates around the axis of the rope,  
14 but does not rotate about its own axis.

15

16 The invention also provides apparatus for use in  
17 handling a load comprising a load-bearing rope, a  
18 mechanism for paying out and recovering the rope, a  
19 cable holder for holding a service cable with a length  
20 of the service cable extending therefrom, and a  
21 wrapping device for rotating said length of service  
22 cable around the rope as the rope is payed out to wrap  
23 the service cable around the rope, and having at least  
24 one slot to facilitate attachment of the apparatus to  
25 the load-bearing rope.

26

27 The invention also provides a method for use in  
28 handling a load, the method comprising paying out a  
29 load-bearing rope and wrapping first and second service  
30 cables around the rope as it is payed out, and  
31 subsequently unwrapping the service cable from the rope

1 as the rope is recovered, wherein one of the service  
2 cables is wrapped over the other.

3

4 Examples of apparatus and a method for use in handling  
5 a load in accordance with the invention will now be  
6 described with reference to the drawings, in which:-

7

8 Fig. 1 is a schematic perspective view  
9 illustrating the principle of operation of a first  
10 winding device;

11 Fig. 2 is a more detailed side view, partly in  
12 section, of an apparatus used in the example of  
13 Fig. 1;

14 Fig. 3 is a view similar to Fig. 1 illustrating a  
15 modification of the arrangement of Fig. 1;

16 Fig. 4 is a schematic perspective view  
17 illustrating a second example;

18 Fig. 5 is a side view of an apparatus used in the  
19 example of Fig. 4;

20 Fig. 6 is a schematic perspective view  
21 illustrating a third example similar to that of  
22 Fig. 1 but modified for towing rather than  
23 lifting;

24 Fig. 7 illustrates a fourth example similar to  
25 that of Fig. 4 but modified for towing rather than  
26 lifting;

27 Fig. 8a is a schematic side view of a fifth  
28 embodiment;

29 Fig. 8b is a close up view of the Fig. 8a  
30 embodiment;

31 Fig. 8c shows in side sectional view some of the  
32 components of the fifth embodiment;



1           Fig. 9a shows a side sectional view of an arm  
2           assembly of the fifth embodiment;  
3           fig. 9b shows a side sectional view of a further  
4           arm assembly of the fifth embodiment;  
5           Figs. 10a and 10b show a side and top view  
6           respectively of a sixth embodiment;  
7           Fig. 11 shows a side view of a sleeve and bearing  
8           of the sixth embodiment;  
9           Fig. 12 shows a plan view of a main support plate  
10          of the sixth embodiment;  
11          Fig. 13 shows a plan view of bearings used in the  
12          sixth embodiment;  
13          Fig. 14 shows a plan view of gears used in the  
14          sixth embodiment;  
15          Fig. 15 shows a plan view of further gears used in  
16          the sixth embodiment;  
17          Fig. 16 shows an exploded side view of the drive  
18          train in the sixth embodiment;  
19          Fig. 17 shows a side view of a gearbox of the  
20          sixth embodiment;  
21          Fig 18 shows a seventh embodiment of a cable  
22          winding device;  
23          Fig 19 shows an eighth embodiment of a cable  
24          winding device;  
25          Fig 20 shows a ninth embodiment of a cable winding  
26          device;  
27          Fig. 21 shows a further embodiment of a winding  
28          device;  
29          Fig 22 shows a further device similar to the Fig.3  
30          device; and  
31          Fig.23 shows a further embodiment of a winding  
32          device.

1 Referring to Fig. 1, a prior art hoist rope 1 extends  
2 from a hoist rope winch 13 over a hoist rope sheave 4  
3 to support a load (not shown) for raising and lowering.  
4 The hoist rope 1 may be any suitable form of hoist rope  
5 such as flexible steel wire rope or synthetic fibre  
6 rope, for example of "Kevlar". A service cable 2 is  
7 reeled on a service cable drum 3 and extends to the  
8 load via a service cable sheave 5.

9  
10 The hoist rope 1 passes through a central aperture of  
11 the service cable drum 3, and the service cable sheave  
12 5 is arranged to be driven circumferentially around the  
13 axis of the service cable 1. By coordinating the  
14 movements of the hoist rope winch 13, the service cable  
15 drum 3 and the service cable sheave 5, the service  
16 cable 2 can be wrapped helically around the hoist rope  
17 1 as the load is lowered, and unwrapped as the load is  
18 raised. In this way, a hoist rope of any desired  
19 properties can be used in combination with any required  
20 service connection.

21  
22 Further service cables on other drums can be added to  
23 be rotated by the motor in different directions.

24  
25 Fig. 2 shows the service cable drum 3 and associated  
26 parts in greater detail. The hoist rope sheave 4 is  
27 journaled to a fixed frame 20 which is secured to any  
28 suitable supporting structure (not shown). The service  
29 cable drum 3 is rotatably mounted on the lower part of  
30 the frame 20 and driven in rotation by a motor 6.

31

1 The inner end of the service cable 2 is connected to  
2 the appropriate service by a coupling assembly 8 which  
3 comprises a slip ring arrangement in the case of  
4 electrical or fibre optic services or a rotary coupling  
5 in the case of pneumatic or hydraulic services; such  
6 rotary couplings are well known per se.

7  
8 The service cable sheave 5 is journalled on a mounting  
9 frame 9 which is rotatable about the fixed frame 20 by  
10 means of a motor 7.

11  
12 The service cable 2 shown in this embodiment may be a  
13 single cable or hose, or may be a specially made cable  
14 comprising a plurality of cable(s)/hose(s).

15  
16 The motors 6 and 7 are driven at speeds related to the  
17 axial speed of the hoist rope 1. The speed correlation  
18 may be fixed. Preferably, however, this correlation  
19 will be controllable to alter both the length of twist  
20 (pitch) of the lay of the service cable 2 on the hoist  
21 rope 1, and the tension in the service cable 2.

22  
23 Fig. 3 shows a modification in which a second service  
24 cable 17 is wrapped on the hoist rope 1 along with the  
25 service cable 2. In this modification, the service  
26 cables 2, 17 are each provided with a respective  
27 storage drum 15, 16 and a respective sheave 5, 14 which  
28 may suitably be carried on a common supporting frame  
29 for rotation in unison. The drum 14 revolves in an  
30 opposite direction to the drum 5 around the rope's  
31 axis, so that the second service cable 17 is wrapped

1 around the rope 1 in the opposite direction to that of  
2 the first cable 2.

3

4 The apparatus may be further modified by adding further  
5 drums and sheaves to handle more services. At least  
6 one service cable is overwrapped on the others, and  
7 this is preferably the last one to be applied so that  
8 the overwrapping cable is at the outer surface of the  
9 wrapped assembly.

10

11 Fig. 4 illustrates a second example in which the  
12 service cable 2 is reeled on a drum 3 and the drum 3 is  
13 itself rotated about the hoist rope 1 to achieve a  
14 helical wrap and unwrap. As shown in more detail in  
15 Fig. 5, the service cable drum 3 may be constituted by  
16 a drum 12 removably mounted on a hub motor 11 which is  
17 carried on the end of an arm 18 rotatably mounted on  
18 the fixed frame 20 and driven by a motor 10.

19

20 As with the first example, the example shown in Figs. 4  
21 and 5 could be modified by adding further service cable  
22 drums to be rotated by the motor 10 in the opposite  
23 direction to the first cable and drum so as to overwrap  
24 the second cable on top of the first.

25

26 Fig. 6 illustrates the example of Fig. 1 modified for  
27 use in a marine towing application, for example in  
28 paying out, towing and recovering a sensor array such  
29 as a sonar sensor or seismographic surveying sensor,  
30 the sensor array being towed underwater or on the  
31 surface. The service cable drum 3 is hinged to the  
32 main structure of the towing vessel (not shown) and can

1 be tilted to a desired towing angle by hydraulic or  
2 other mechanisms. Likewise, Fig. 7 illustrates the  
3 modification of the example of Fig. 4 for the same use,  
4 the frame carrying the mounting arm for the service  
5 cable drum 3 being hinged to the vessel and tilted to  
6 the desired angle by hydraulic or other mechanisms.

7  
8 The invention may be applied to a system in which one  
9 or more service cables is applied to a load-bearing  
10 rope which itself carries a service channel in addition  
11 to fulfilling its load-bearing function. For example,  
12 the load-bearing rope could be a steel wire rope  
13 carrying electrical signals, or a rope comprising  
14 "Kevlar" load-bearing strands in combination with  
15 optical fibre cable.

16  
17 Fig. 8 discloses a further embodiment of the invention  
18 having first and second drums 31 and 32 which are  
19 arranged to rotate around a load-bearing rope 35 in  
20 different directions and can wind different cables (for  
21 example a fibre optic communications cable and a high  
22 voltage power cable) in opposite directions around the  
23 central load-bearing rope 35. This has been found by  
24 the inventor to be useful particularly in applications  
25 where the load-bearing rope 35 remains slack during  
26 certain periods in the operation of the equipment. By  
27 contra-rotating the cables around the load-bearing rope  
28 they are less likely to move or become loose should the  
29 load-bearing rope 35 slacken. In addition, a fragile  
30 cable such as a fibre optic cable wound around the  
31 load-bearing rope 35 in a first direction can be  
32 overlaid by e.g. a high voltage power cable wound

1 around the load-bearing rope 35 and fibre optic cable  
2 in the opposite direction, and this can also afford  
3 some protection to fragile cables such as fibre optics  
4 etc.

5

6 In the Fig. 8 apparatus, two different cables wound  
7 onto respective drums 31 and 32 are paid out while the  
8 drums are rotated around the load-bearing rope 35.

9

10 Drum 31 is mounted on an arm 40 connected to an arm  
11 assembly 41 having a top hat structure with a top  
12 surface, and an annular flange 41f provided at the  
13 lower end of side walls 42s (shown in Fig. 9). The arm  
14 assembly 41 has a central aperture 42 in its top  
15 surface through which the load-bearing rope 35 passes,  
16 and has an annular bevel gear 43 cut into the outer  
17 edge of its top surface.

18

19 A second drum 32 is supported on a further arm 50 also  
20 connected to an arm assembly 51 having a similar top  
21 hat structure and shown in Fig. 9b. Arm assembly 51  
22 comprises a lower annular flange 51f with a sleeve 51s  
23 attached thereto and having a central bore 51b  
24 extending through the sleeve 51s and through the  
25 annular flange 51f. A bevel gear 53 (shown in Fig. 9a)  
26 is manufactured separately but located over the sleeve  
27 51s and fixed in place by any suitable means, for  
28 example by welding or bolting or other fixing means  
29 after the apparatus has been assembled.

30

31 The Fig. 8 apparatus is assembled by locating the arm  
32 assembly 41 and a pair of bearing rings 44 over the

1 sleeve 51s, so that the arm assembly 41 is capable of  
2 rotating on the bearings around the sleeve 51s. A slip  
3 ring 55 for transmitting electric or hydraulic power  
4 via the rotating arm assembly 41 and arm 40 to the drum  
5 31 is then located over the ring 41 to rest on the  
6 flange 41f. Slip rings suitable for this and other  
7 purposes of the invention are known and suitable  
8 electrical, fibre optic and fluid rotary union slip  
9 rings are available e.g. from Focal Technologies Inc of  
10 40 Thornhill Drive, Unit 7 Dartmouth, Nova Scotia,  
11 Canada B3B 1S1. Such slip rings for electrical, fibre  
12 optic and hydraulic power transmission are clearly  
13 readily available and will not be described further  
14 here.

15  
16 Bevel ring 53 is then offered to the sleeve 51s and  
17 attached thereto in opposite orientation to bevel gear  
18 43. A further slip ring 56 is located on top of the  
19 bevel ring 53 in order to transmit power from a  
20 stationary source via the sleeve 51s, flange 51f and  
21 arm 50 to the drum 32.

22  
23 Bearing rings 45 are then located over the sleeve 51s  
24 and a support bracket 58 is placed around them and  
25 attached to the ship or other structure from which the  
26 apparatus is to be used. The support bracket 58  
27 likewise has an annular flange 58f and an aperture 58a  
28 for the sleeve 51s. A top ring 60 having a central  
29 aperture for the through passage of the rope 35 is then  
30 bolted to the upper face of the sleeve 51s, and secures  
31 the annular apparatus together around the central  
32 sleeve 51s.

1  
2 On flange 58f of the support bracket 58 a motor 62  
3 drives a shaft 63 to a gearbox 64 disposed below the  
4 bracket 58 but above the lower slip ring 55. The motor  
5 62 and gearbox 64 transmit power via shaft 65 between  
6 the slip rings to a bevel gear drivehead 66. Bevel  
7 drivehead 66 engages bevel rings 53 and 43 and drives  
8 them in opposite directions simultaneously. By a  
9 single force exerted from the motor 62, the arms 40 and  
10 50 and therefore the drums 31 and 32 can thus be driven  
11 in opposite contra-rotating directions around the  
12 central axis of the load-bearing rope 35 as it is payed  
13 out (described previously).  
14  
15 The bearings 44, 45 support the arm assemblies 41 and  
16 51 so that they can rotate within the main support  
17 bracket 58 attached to the ship or other structure.  
18  
19 The winch drums 31 and 32 can hoist and lower cables by  
20 use of electric or hydraulic power transmitted through  
21 the slip rings 55, 56. Conventional power cables (or  
22 hydraulic conduits if hydraulic motors are used) can be  
23 passed through the drum support arms 40 and 50 from the  
24 inner half of the slip ring adapters which will remain  
25 stationary in relation to the arms 40, 50.  
26  
27 Although the embodiment shown in Figs. 8 & 9 is driven  
28 through motor 62 and bevel gear 66, the apparatus could  
29 also be driven from the sleeve 51s which could in  
30 certain embodiments protrude out of the securing plate  
31 and be rotated using belts, gears, chains or similar  
32 mechanisms. The bevel gear arrangement shown in Figs.



1 8 & 9 would in that embodiment still remain to contra-  
2 rotate the drums under the power applied to the sleeve  
3 51s and therefore bevel gear 53.

4  
5 The drums could also be driven independently using two  
6 separate motors. One motor at the top of the sleeve  
7 51s as mentioned above could drive the arm 50, and the  
8 motor 62 could drive the arm assembly 41 through the  
9 bevel gear 66. That embodiment would not require the  
10 additional bevel ring 53, which could be removed.

11  
12 A further improved variant of the invention is shown in  
13 the remaining Figs. 10 to 17, Components of the  
14 mechanism shown in these figures are slotted so that  
15 the apparatus can be deployed or recovered without  
16 first having to pass the load-bearing rope through the  
17 centre of the mechanism. The load-bearing rope can  
18 instead be removed or replaced within the mechanism  
19 during any part of the operation. This is particularly  
20 useful with heavy and oversized pieces of equipment.  
21 The slots can be filled by removable segments which are  
22 replaced after the load-bearing rope has been located  
23 within the mechanism. This has the advantage of  
24 allowing more traditional slip rings and the segment  
25 could be located easily within a tapered notch. Single  
26 gear driving would then be possible, but it is also  
27 equally possible to drive a slotted mechanism by two or  
28 more gears as shown in the drawings and described  
29 below. The embodiment shown and described is not  
30 affected by the notches, and these allow the load-  
31 bearing rope to be removed or placed within the  
32 mechanism as required without removal of the notch

1 filling segment. More than one drive shaft is  
2 preferable to reduce the possibility of contact being  
3 lost with the centre drive when the notch thereon  
4 passes the driving wheel. In the embodiments shown,  
5 all of the parts which rotate around the load-bearing  
6 rope 35 are slotted.

7  
8 Referring now to Figs. 10 to 17, a central rotating  
9 notched sleeve 151, having an annular flange 151f on  
10 its outer surface is provided. The sleeve 151 is  
11 notched at 15 to allow radial passage of the rope 35  
12 through the notch 15 into the axial bore. An annular  
13 thrust bearing 170 separates the lower surface of the  
14 flange 151f from a main support plate 175 through which  
15 it passes via a central aperture 175a, also notched.  
16 The main support plate 175 also has two side apertures  
17 175b and c through which the drive shafts of motors 176  
18 and 177 pass.

19  
20 A main support bearing 179 surrounds the outer surface  
21 of the sleeve 151 above the flange 151f.

22  
23 Motor 176 drives winding gear 180 which is used to  
24 drive the winding of the rope around the central load-  
25 bearing rope 35. Winding gear 180 is a circular gear  
26 driving two further gears 181, 182 in the same  
27 direction. Gear train 180, 181, 182 drives a spur gear  
28 185 also having a notch 15 coinciding with the notch 15  
29 in the sleeve 151, and keyed to the sleeve 151 by means  
30 of a keyway 185k. Rotation of gear train 180, 181, 182  
31 therefore drives spur gear 185 and (by virtue of the  
32 keyway) sleeve 151. Since the gears 181 and 182 are

1 spaced apart, the notching of the assembly of the spur  
2 gear 185 and sleeve 151 does not affect power  
3 transmission to the sleeve 151, since even if the notch  
4 15 is adjacent one of the gears 181, 182, the other  
5 will still be contacting the teeth and will transmit  
6 power to the sleeve 151 for the time taken for the  
7 notch 15 to pass the gear 181 or 182 as the case may  
8 be.

9  
10 A drum 190 is carried on a support arm 191 attached to  
11 the lower end of the sleeve 151 and therefore rotation  
12 of the drive train 180, 181, 182 by the motor 176  
13 drives rotation of the arm 191 around the central axis  
14 of the load-bearing rope, thereby winding the cable on  
15 the drum 190 axially around the load-bearing rope 35 as  
16 it is payed out as described previously.

17  
18 Hoist and payout of the cable on the drum 190 is driven  
19 by motor 177 through the drive train to be described  
20 below. Motor 177 has a driveshaft 177d passing through  
21 the aperture C in the main support plate 175. A spacer  
22 178 spaces a gear 200 driven by shaft 177d from the  
23 lower surface of the main support plate 175. Gear 200  
24 is part of a drive train 200, 201, 202 similar to the  
25 drive train 180, 181, 182 as previously described.  
26 Drive train 200, 201, 202 drives the rotation of a  
27 notched spur gear 205 having a slot 15 and located  
28 around the sleeve 151 on a bearing 203. The spur gear  
29 205 is able to rotate relative to the sleeve 151, and  
30 is driven around the sleeve by the operation of the  
31 drive train 200, 201, 202. The drive train 200, 201,  
32 202 meshes with an upper row of teeth 206 on the gear

1 205. Spur gear 205 also carries a lower row 207 of  
2 teeth which are clearly also driven in rotation by  
3 operation of the drive train 200, 201, 202. A further  
4 set of gears 210, 211, 212 mesh in a fashion similar to  
5 that described for the gears 180, 181, 182 with the  
6 lower teeth 207 of the spur gear 205. The gear 210 is  
7 located on a drive shaft connected to a right angled  
8 gearbox 215 where a bevel gear or similar arrangement  
9 drives rotation of a perpendicular second shaft 216,  
10 which through a pulley wheel drives the rotation of the  
11 drum 190 around its own axis by a belt, chain or  
12 similar such means. This allows the motor to hoist in  
13 or lower the power or signal cable on the drum. The  
14 gear box 215 is mounted on the drum support arm 191,  
15 which is held in place by a notched securing nut 220.

16  
17 The locating C nut 220 secures the winch support arm,  
18 the double row toothed gear 205 the single row toothed  
19 gear and two shims, which all slide up onto the lower  
20 half of the central rotating notched cylinder 17.

21  
22 More than one drum can be provided on the embodiment  
23 described, and where two drums are provided, they can  
24 be rotated in opposite directions.

25  
26 The central rotating notched cylinder is held in  
27 position by the thrust bearing and the main support  
28 bearing within which it can rotate freely.

29  
30 The main support plate is attached to the ship or other  
31 structure and provides the support for the motors and

1 the bearing housings for the main support bearing and  
2 thrust bearing.

3

4 All components preferably have a notch cut in them to  
5 allow the load-bearing rope to be swung into the  
6 mechanism. By use of the motor to rotate the winch  
7 drum around the load-bearing rope the central rotating  
8 notch can be lined up with the notch in the bearings  
9 and the main support plate. Using the motor to rotate  
10 the gear its notch can also be aligned and the load-  
11 bearing rope can either be placed within the mechanism  
12 or removed from it.

13

14 The teeth on the gears 180; 181; 182 etc can be  
15 replaced by a pulley system such as that shown in Fig.  
16 14c which uses a notched belt 185b running on gears  
17 180'; 181'; 182' driving gear 185'.

18

19 The motors used for driving any of the presently  
20 described embodiments can be of any suitable type.  
21 Conventional motors available for many years are  
22 eminently suitable, and any standard electric or  
23 hydraulic motors available for over 15 years by any of  
24 the manufacturers Charlin, Eaton, White, Mannesmann  
25 Rexroth, Hawker Sidley and many others are suitable.  
26 Various different kinds of motors available for the  
27 winch and frame driving motors etc will be well known  
28 to one of moderate skill in the art.

29

30 Fig. 18 shows a further device having a first drum 350u  
31 arranged above a second lower drum 350l, both of which  
32 are arranged around a load-bearing rope 1 which passes

1 through their axes. The drums 350 each have a  
2 respective arm 359u/359l and spooling gear 360u/360l  
3 which spools off the cables in the upper and lower  
4 drums in different directions and can wind different  
5 cables (for example a fibre optic communications cable  
6 on the upper drum 350u and a high voltage power cable  
7 on the lower drum 350l) in opposite directions around  
8 the central load-bearing rope 1 in the same manner as  
9 the embodiment described with regard to Fig. 8 and 9.

10

11 In the Fig. 18 apparatus, two different cables wound  
12 onto respective drums 350u and 350l are paid out while  
13 the arms 359u/359l rotate around the load-bearing rope  
14 1.

15

16 Drums 350u have a top hat structure with a pair of  
17 annular flanges provided at the lower end of side  
18 walls. The cable is stored between the annular  
19 flanges, and the side walls define a cylinder through  
20 which the hoist rope 1 can pass axially. The arms 359  
21 are each mounted on a sleeve with an annular bevel gear  
22 cut into an opposing edge to allow a single bevel  
23 drivehead 360 to drive each of the arms in opposite  
24 directions. The same or a different bevel drivehead  
25 can be used for each. Bevel drivehead 360 engages  
26 bevelled edges on the arms 350 and drives them in  
27 opposite directions simultaneously. By a single force  
28 exerted from a motor (not shown), the arms can thus be  
29 driven in opposite contra-rotating directions around  
30 the central axis of the load-bearing rope 1 as it is  
31 payed out.

32

1 The drums are hung on a frame 320 which holds bearings  
2 and slip rings as previously described.

3

4 Although the embodiment shown in Fig. 18 is driven  
5 through a motor and bevel gear 360, the apparatus could  
6 also be driven from a sleeve forming part of an arm or  
7 a drum and which could in certain embodiments protrude  
8 out of the assembly and be rotated using belts, gears,  
9 chains or similar mechanisms. The bevel gear  
10 arrangement shown in Fig 18 could in that embodiment  
11 still remain to contra-rotate the arms under the power  
12 applied to the sleeve and therefore bevel gear 360.

13

14 The arms could also be driven independently using two  
15 separate motors.

16

17 Fig 19 shows a further cable winding device which has a  
18 trough 5t rather than a drum 5 for storing the service  
19 cable 2. This is very useful for very thick or heavy  
20 cables not suitable for storage on a drum 5. The  
21 trough 5t is provided with spooling gear in the form of  
22 sheaves and can optionally incorporate tensioning  
23 devices such as a linear winch e.g. a pair of tyres  
24 through which the cable can run and which retard the  
25 cable thereby tensioning it slightly. A further trough  
26 can be added to provide another service cable to be  
27 wrapped around the rope in the opposite direction to  
28 that of the first cable.

29

30 Fig 20 shows a further cable winding device which  
31 dispenses with the need for slip rings. The Fig 20  
32 device is suitable for cables which will withstand a

1 twist every turn or a pretwisting of the cable before  
2 it is run onto the drum. The turns per metres of the  
3 cable paid out will be dependant on the diameter of the  
4 cable on the cable winch.

5  
6 In the Fig 20 device the signal/power service cable can  
7 be wound from a power supply or other service  
8 connection (not shown) via several guide sheaves onto a  
9 first drum 5s of small diameter. The small diameter  
10 drum 5s can be located on an upper part of the winch  
11 drum which can either be turned by a motor, or can  
12 remain stationary with an arm revolving to unwrap the  
13 cable from it. The purpose of the small diameter drum  
14 is to allow limited movement on the main drum as the  
15 hoist rope may twist thereby requiring more turns of  
16 the signal/power cable drum than were originally put  
17 onto the hoist rope as it was paid out.

18  
19 The cable 2 is typically paid out from the main cable  
20 winch drum 5l by a rotating arm 9a rotating in a  
21 direction which unwinds the cable 2 from the drum 5l.  
22 The rotating arm 9a rotates in the opposite direction  
23 to wind on the cable 2. The arm 9a can be set to pay  
24 out at a preset tension and hoist if the tension is  
25 less than that preset tension.

26  
27 In the Fig 20 device, the service cable 2 is connected  
28 to the service (power signal etc) and wound first onto  
29 the small drum 5s. An aperture in the small drum wall  
30 allows the cable 2 to pass into the axial bore of the  
31 drum 5 where it runs parallel to the rope 1 to the  
32 level of the main lower drum 5l. It passes through the



1 wall of the main drum 51 and onto the spool from which  
2 it is unwound by the spooling gear on the rotating arm  
3 9a in much the same manner as has been described  
4 previously. The cable can be applied to the drum 5  
5 with a pretwist so as to avoid kinking in the cable  
6 during use.

7

8 Further signal cables can be applied to the rope using  
9 the Fig.20 device.

10

11 In other embodiments the cable drum can be arranged to  
12 rotate around the rope and/or can rotate on its own  
13 horizontal axis in order that the rope can be spooled  
14 off in a similar manner to other embodiments.

15

16 Fig. 21 illustrates a further embodiment in which the  
17 service cable 2 is reeled on a drum 3 and the drum 3 is  
18 itself rotated about the hoist rope 1 to achieve a  
19 helical wrap and unwrap. The service cable drum 3 may  
20 be constituted by a drum 12 removably mounted on a hub  
21 motor 11 which is carried on the end of an arm 18  
22 rotatably mounted on a fixed frame 20 and driven by a  
23 motor 10. The arm 18 has a hinge 18h connecting it to  
24 the frame 20 and a hydraulic ram 18r to pivot the arm  
25 18 about the hinge 18h relative to the frame 20 from  
26 the lower position shown in Fig 2 to the higher  
27 position, so as to move the cable drum 3 out of the way  
28 of large loads being lifted by the hoist rope 1.

29

30 Further service cable drums could be added to be  
31 rotated by the motor 10.

32

1 Fig. 22 shows a further embodiment similar to the Fig.2  
2 embodiment in which the service cable drum 3 is  
3 rotatably mounted on the lower part of the frame 20  
4 with the rope 1 passing through an axial aperture in  
5 the cable drum 3 and driven in rotation by a motor 6.  
6 The arm of the mounting frame 9 has a hinge 9h and a  
7 hydraulic ram 9r connecting two shoulders on opposite  
8 sides of the hinge 9h. The ram can be activated to  
9 draw the sheave-bearing part of the arm 9 upwards out  
10 of the way of large objects being lifted.

11  
12 Fig 23 shows a further embodiment in which the service  
13 cable 2 is held on a drum 5a which is fixed to an arm  
14 30 that can rotate about the axis of the rope 1. The  
15 drum 5a does not need to be rotatably mounted on the  
16 arm 30 so that it rotates on its own axis but instead  
17 has a further arm 31 that rotates about the axis of the  
18 drum 5a and carries the cable via spooling gear 32 to  
19 the rope 1.

20  
21 The drum 5a may have a tapered surface and this  
22 provides another aspect of the invention.

23  
24 Other modifications may be made within the scope of the  
25 invention.

1     CLAIMS

2

3     1.   Apparatus for use in handling a load comprising a  
4     load-bearing rope, a mechanism for paying out and  
5     recovering the rope, a first cable holder for holding a  
6     first service cable with a length of the first service  
7     cable extending therefrom, a second cable holder for  
8     holding a second service cable with a length of the  
9     second service cable extending therefrom, and a  
10    wrapping device for rotating said lengths of service  
11    cable around the rope as the rope is payed out to wrap  
12    the service cables around the rope, wherein one of the  
13    first and second service cables is wrapped over the  
14    other.

15

16    2    Apparatus according to claim 1, wherein each  
17    service cable holder comprises a drum.

18

19    3    Apparatus according to claim 1 or claim 2, wherein  
20    the wrapping device can recover the service cables to  
21    their respective cable holders during recovery of the  
22    rope and cables.

23

24    4    Apparatus according to any preceding claim,  
25    wherein the mechanism for paying out and recovering the  
26    rope comprises a rope sheave and a rope winch, and  
27    wherein the rope passes from the rope winch over the  
28    rope sheave and thereafter extends to the load along a  
29    substantially straight axis.

30

31    5    Apparatus according to any preceding claim,  
32    wherein the wrapping device comprises the or each

1 service cable holder being arranged for rotation about  
2 an axis which coincides with the axis of the rope.

3  
4 6 Apparatus according to any preceding claim,  
5 wherein the or each service cable holder has a central  
6 aperture through which the load-bearing rope passes.

7  
8 7 Apparatus according to claim 4 or any claim  
9 dependent thereon, comprising a service cable sheave  
10 rotatably mounted on the apparatus and capable of  
11 movement in a circular path around the substantially  
12 straight axis, and wherein the length of service cable  
13 passes over the service cable sheave.

14  
15 8 Apparatus according to claim 4 or any claim  
16 dependent thereon, having a structural member upon  
17 which the or each service cable holder is rotatable,  
18 the or each structural member being arranged for  
19 movement in a circular path about said substantially  
20 straight axis.

21  
22 9 Apparatus according to claim 4 or any claim  
23 dependent thereon, wherein the rope winch, the or each  
24 service cable drum and the wrapping device each have a  
25 respective driving motor.

26  
27 10 Apparatus according to claim 4 or any claim  
28 dependent thereon, wherein the rope winch, the or each  
29 service cable drum and the wrapping device are driven  
30 by a single source through appropriate mechanical  
31 linkages.

32

1 11 Apparatus according to any preceding claim,  
2 wherein each service cable has a respective service  
3 cable sheave being capable of rotation in opposite  
4 directions to one another.  
5

6 12 Apparatus as claimed in any preceding claim,  
7 wherein the service cables are overwrapped in the same  
8 direction but at different pitches.  
9

10 13 Apparatus for use in handling a load comprising a  
11 load-bearing rope, a mechanism for paying out and  
12 recovering the rope, a cable holder for holding a  
13 service cable with a length of the service cable  
14 extending therefrom, and a wrapping device for rotating  
15 said length of service cable around the rope as the  
16 rope is payed out to wrap the service cable around the  
17 rope, and having at least one slot to facilitate  
18 attachment of the apparatus to the load-bearing rope.  
19

20 14 Apparatus as claimed in claim 13, wherein the or  
21 each slot extends axially on one or more components of  
22 the apparatus.  
23

24 15 Apparatus as claimed in claim 13, wherein at least  
25 one component having a slot is driven in rotation by a  
26 drive train having more than one point of contact with  
27 said at least one component.  
28

29 16 Apparatus as claimed in claim 15, wherein the  
30 drive train comprises at least two transmission gears  
31 which contact said at least one component at spaced-  
32 apart locations.

1

2 17 Apparatus as claimed in claim 15 or 16, wherein  
3 the drive train comprises a belt driven by a driver and  
4 contacting said at least one component in at least two  
5 spaced-apart locations.

6

7 18 A method for use in handling a load, the method  
8 comprising paying out a load-bearing rope and wrapping  
9 first and second service cables around the rope as it  
10 is payed out, and subsequently unwrapping the service  
11 cable from the rope as the rope is recovered, wherein  
12 one of the service cables is wrapped over the other.

13

14 19 A method as claimed in claim 18, wherein the  
15 service cables are wrapped around the load-bearing rope  
16 in opposite directions.

17

18 20 A method as claimed in claim 16, including the  
19 steps of attaching the load-bearing rope to a mechanism  
20 for paying out and recovering the load-bearing rope,  
21 attaching the load-bearing rope to the load, and  
22 subsequently attaching to the load-bearing rope  
23 apparatus for wrapping the service cable around the  
24 load-bearing rope, wherein the wrapping apparatus has  
25 at least one axial notch through which the load-bearing  
26 rope passes as the wrapping device is being attached to  
27 the load-bearing rope.

28

29 21 Apparatus for use in handling a load comprising a  
30 load-bearing rope, a mechanism for paying out and  
31 recovering the rope, a drum for holding a service cable  
32 with a length of the service cable extending therefrom,

1 and a wrapping device for rotating said length of  
2 service cable around the rope as the rope is payed out  
3 to wrap the service cable around the rope, and to  
4 unwrap the service cable from the rope as the rope is  
5 recovered, wherein the wrapping device rotates around  
6 the axis of the rope, but does not rotate about its own  
7 axis.

8  
9 22 Apparatus for use in handling a load comprises a  
10 load-bearing rope, a mechanism for paying out and  
11 recovering the rope, a mechanism for holding and paying  
12 out a service cable, and a wrapping device for rotating  
13 one of the service cable and the rope around the other  
14 as they are payed out to wrap the said one of the  
15 service cable and the rope around the other, and to  
16 unwrap one of the service cable and the rope from the  
17 other as it is recovered, wherein at least part of the  
18 wrapping device can be moved to accommodate large  
19 objects.

20

1 / 26

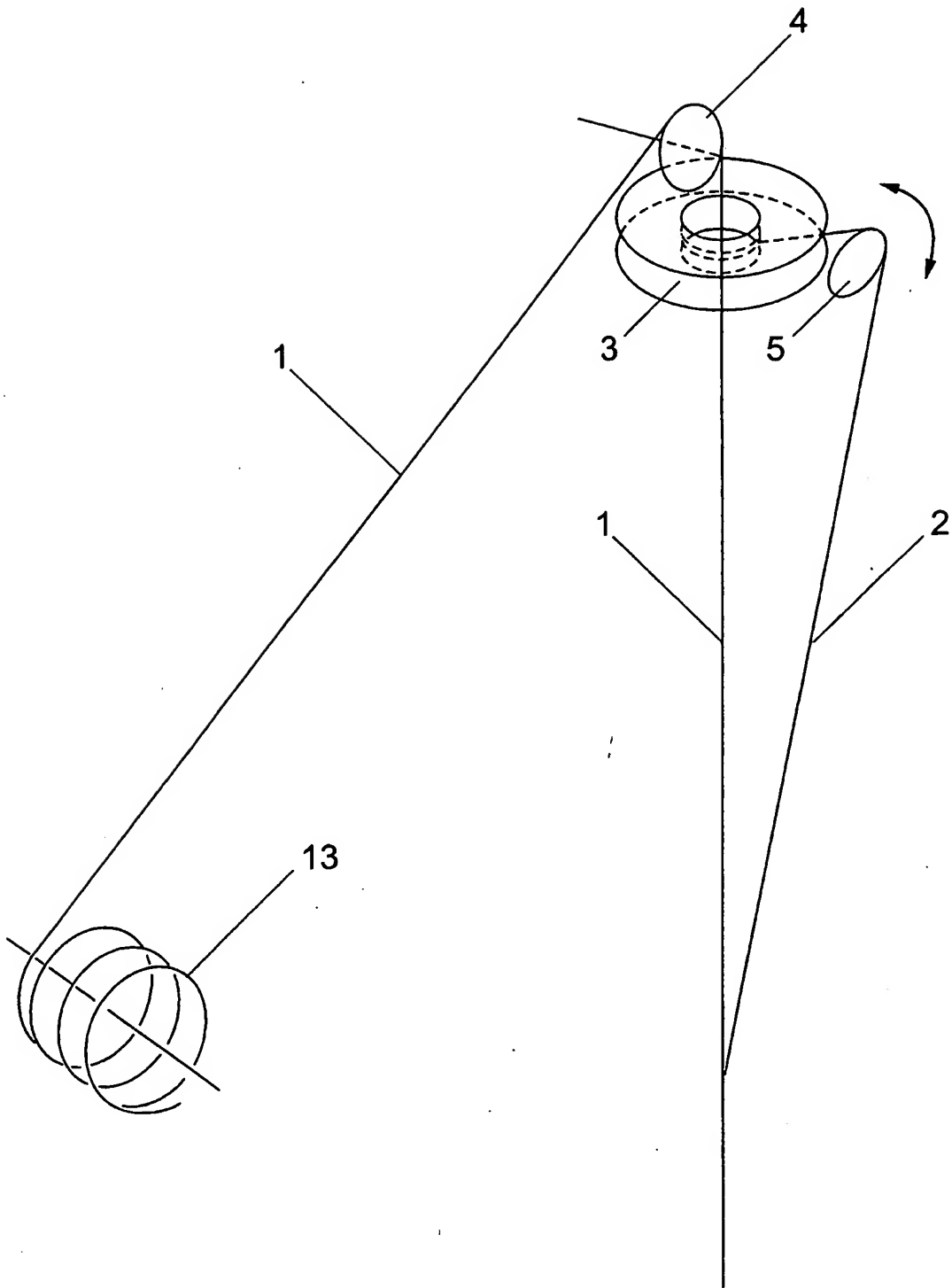


Fig. 1



2 / 26

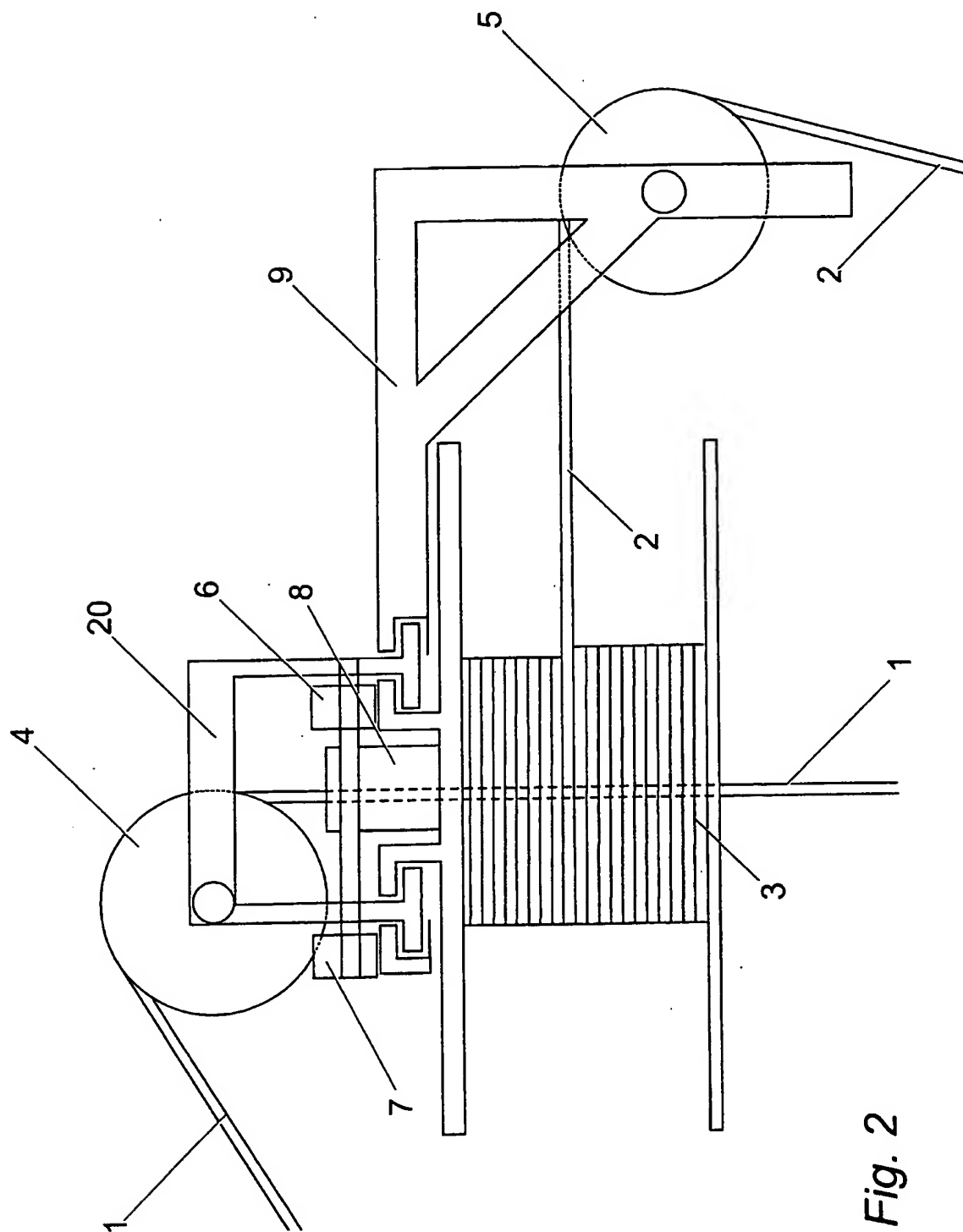


Fig. 2

3 / 26

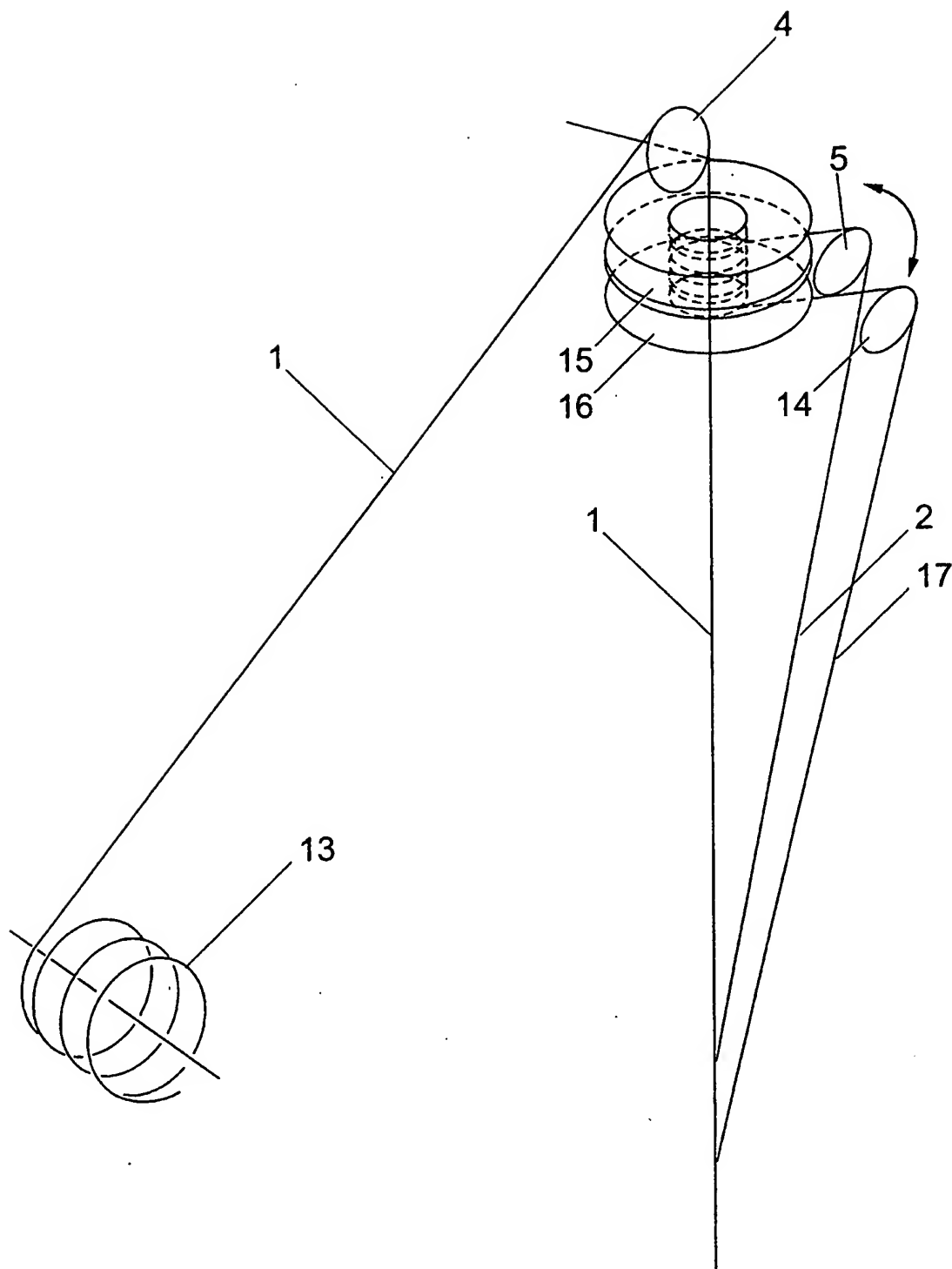


Fig. 3

4 / 26

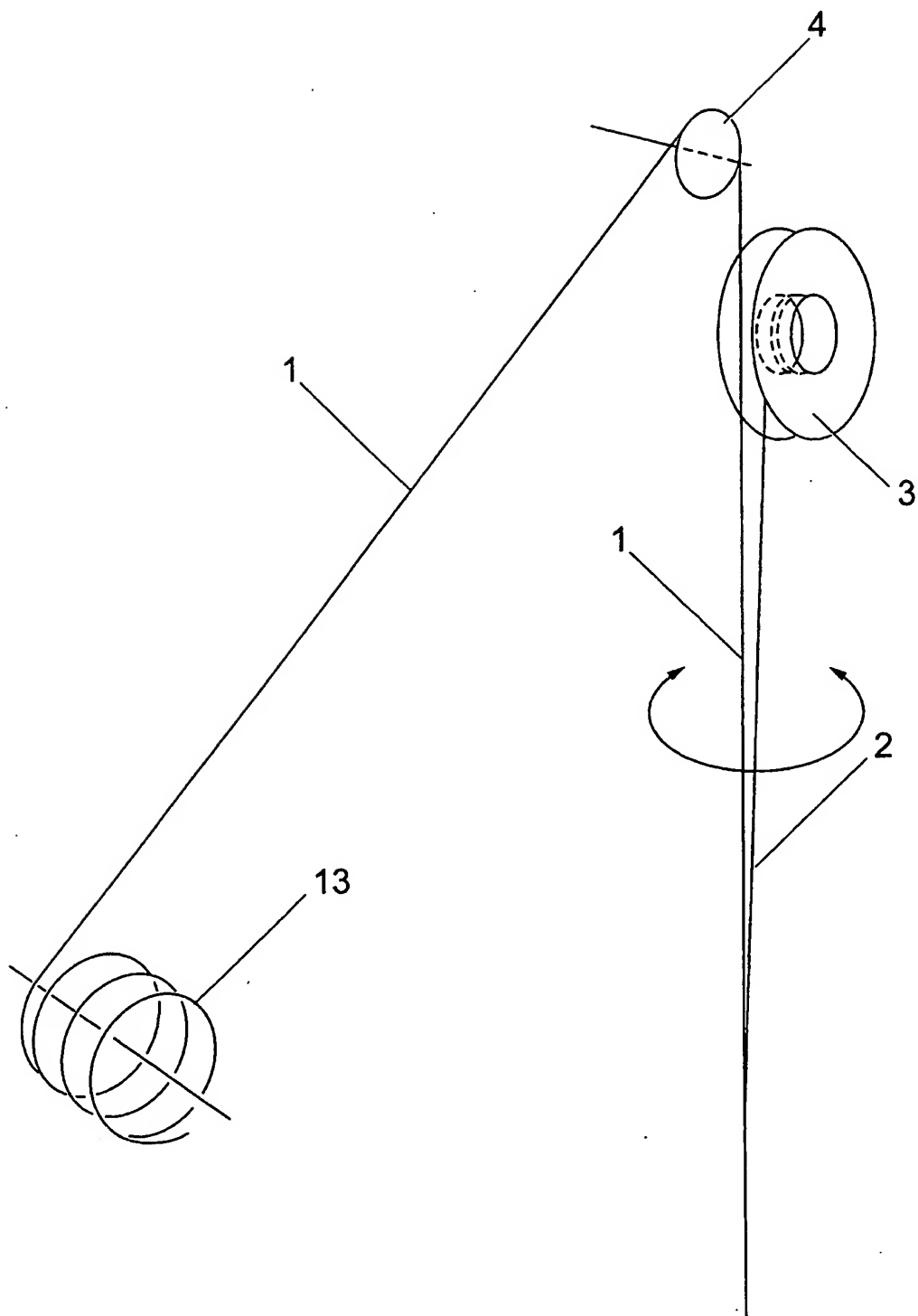
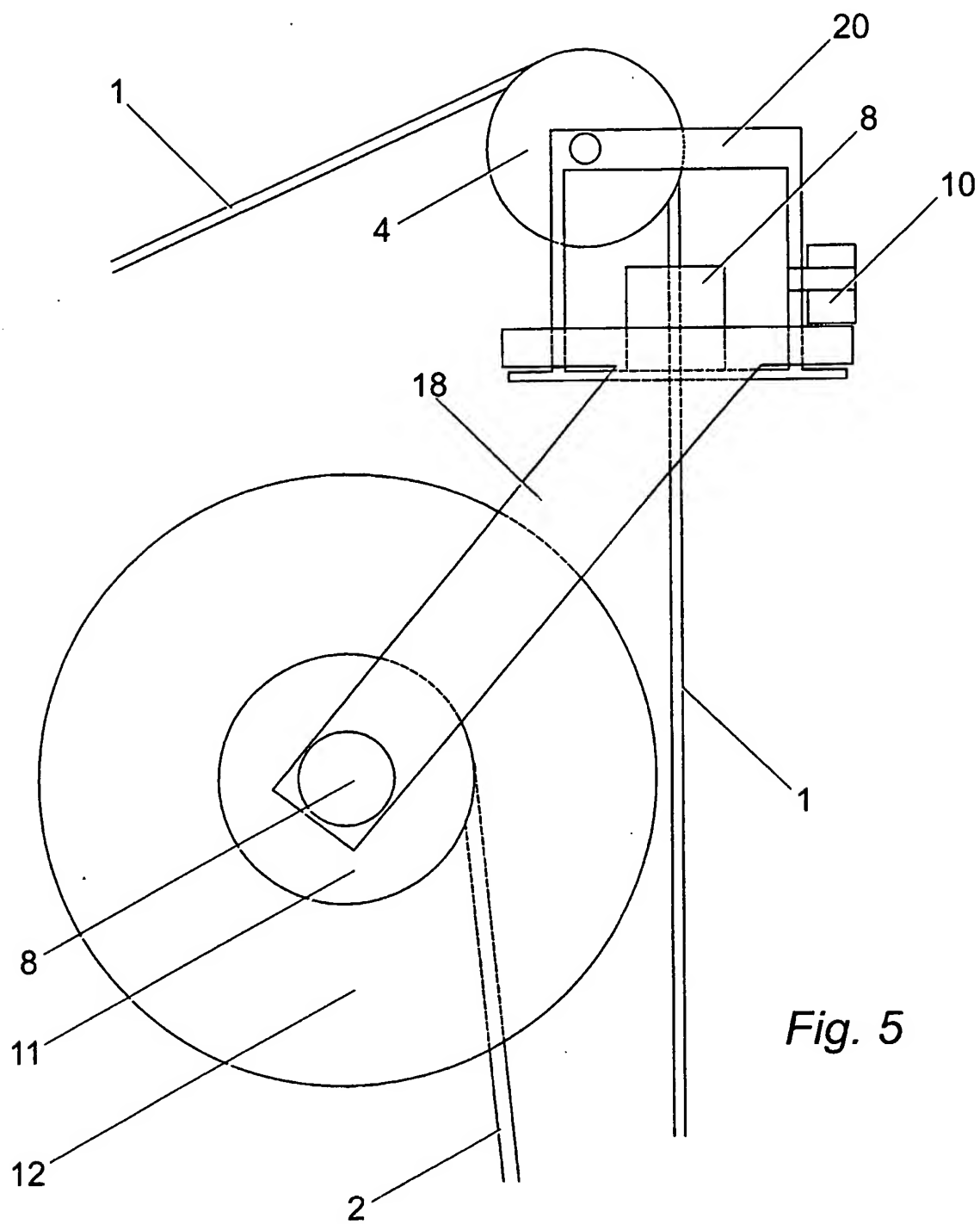


Fig. 4

5 / 26



6 / 26

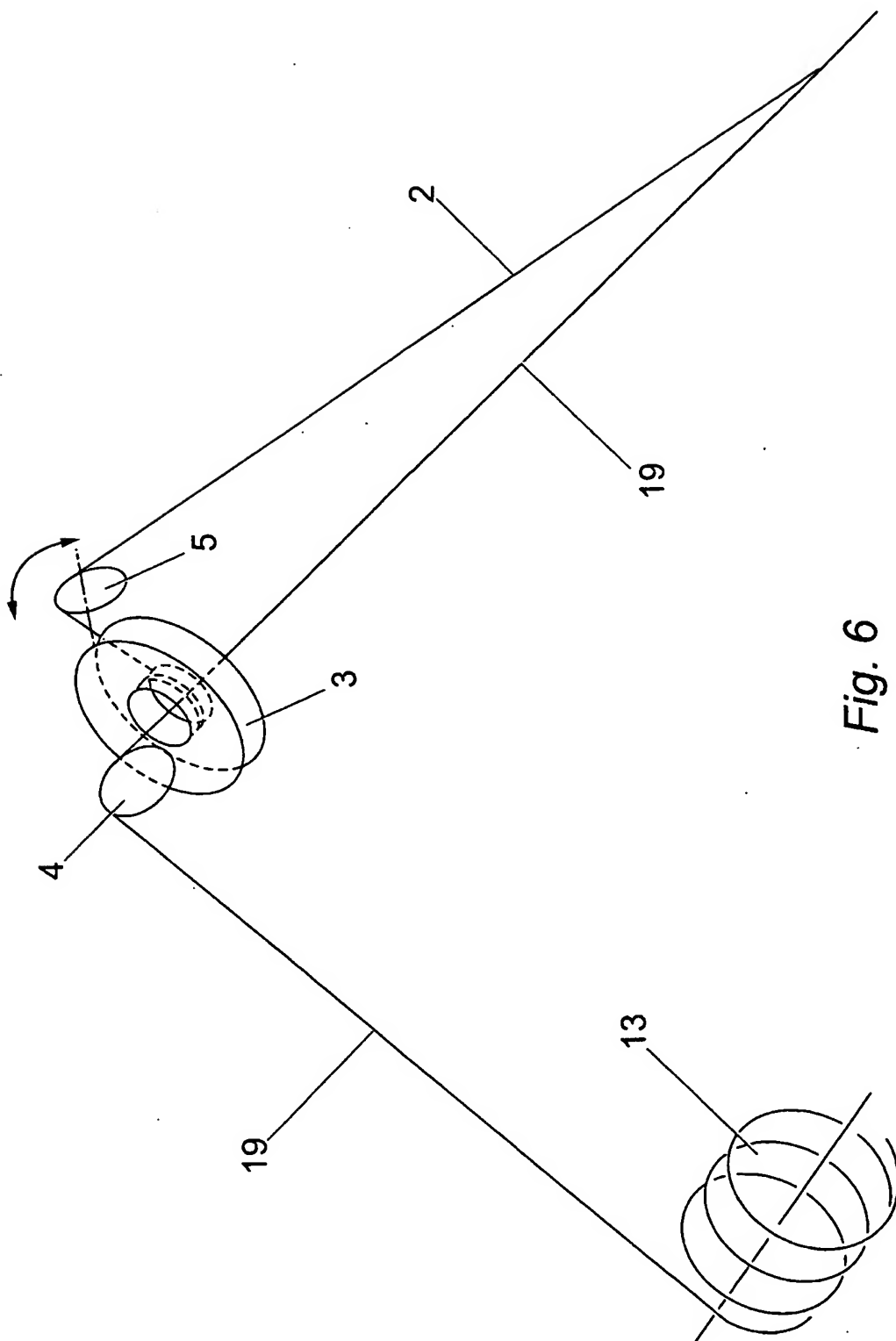
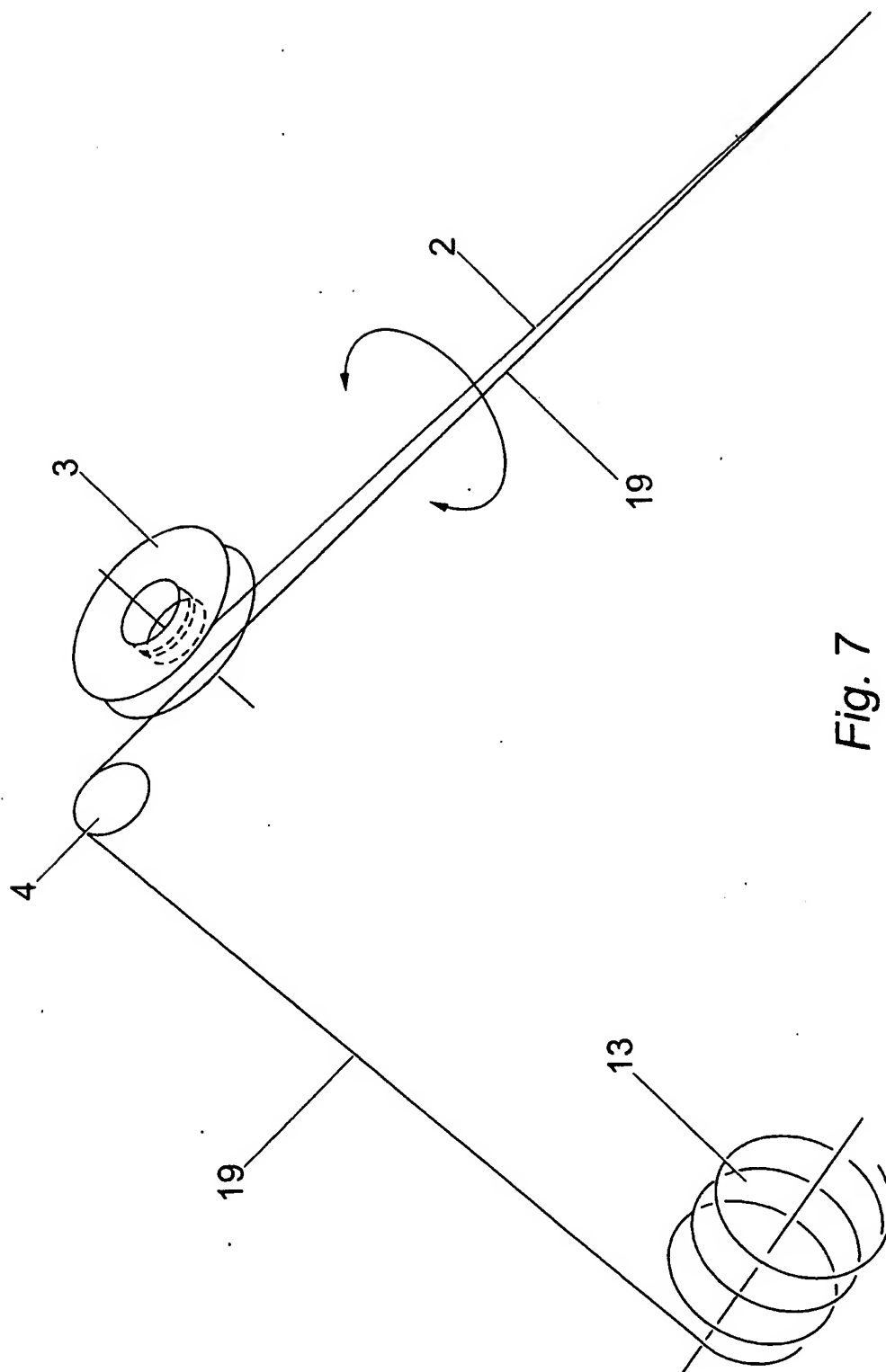
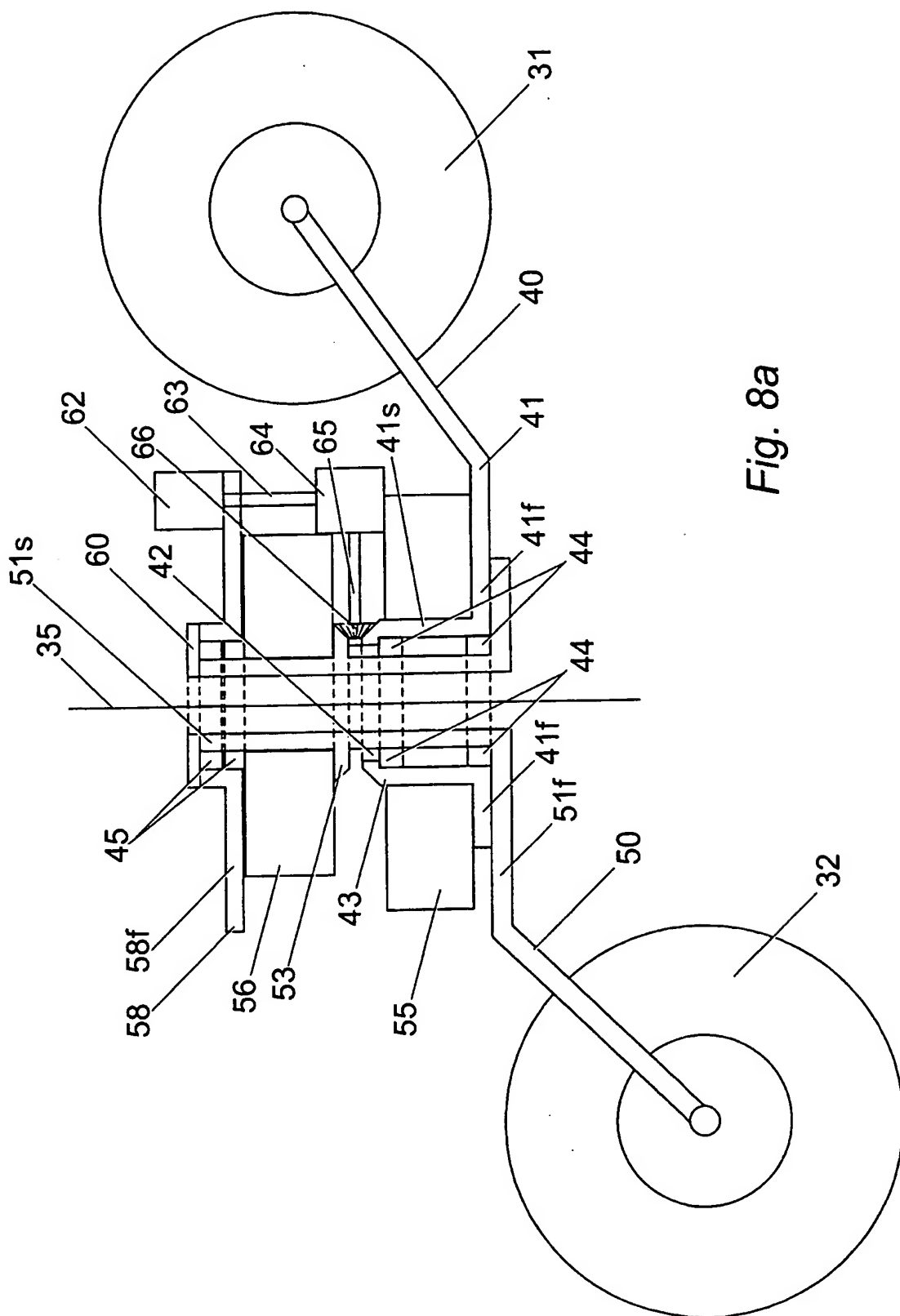


Fig. 6

7 / 26

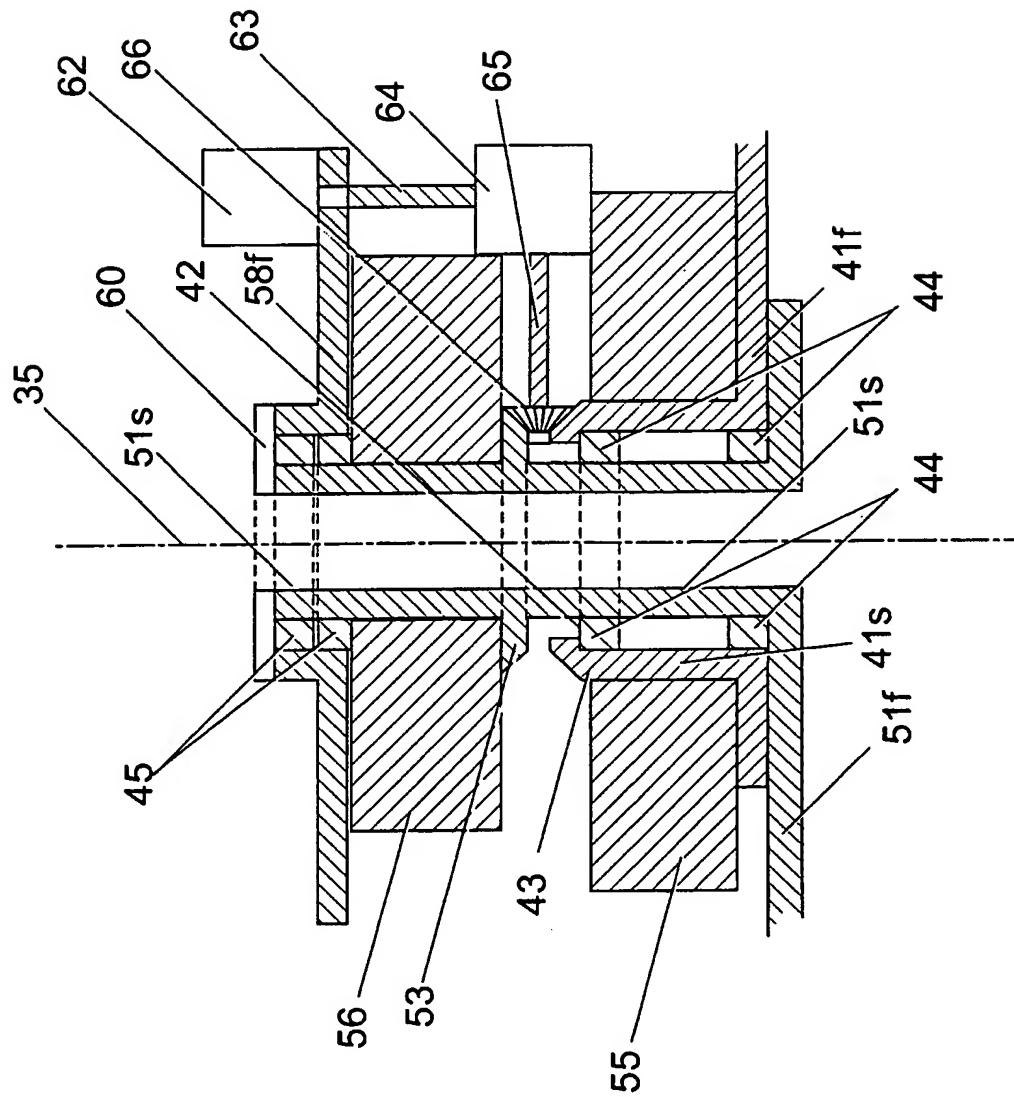


8 / 26



9 / 26

Fig. 8b





10 / 26

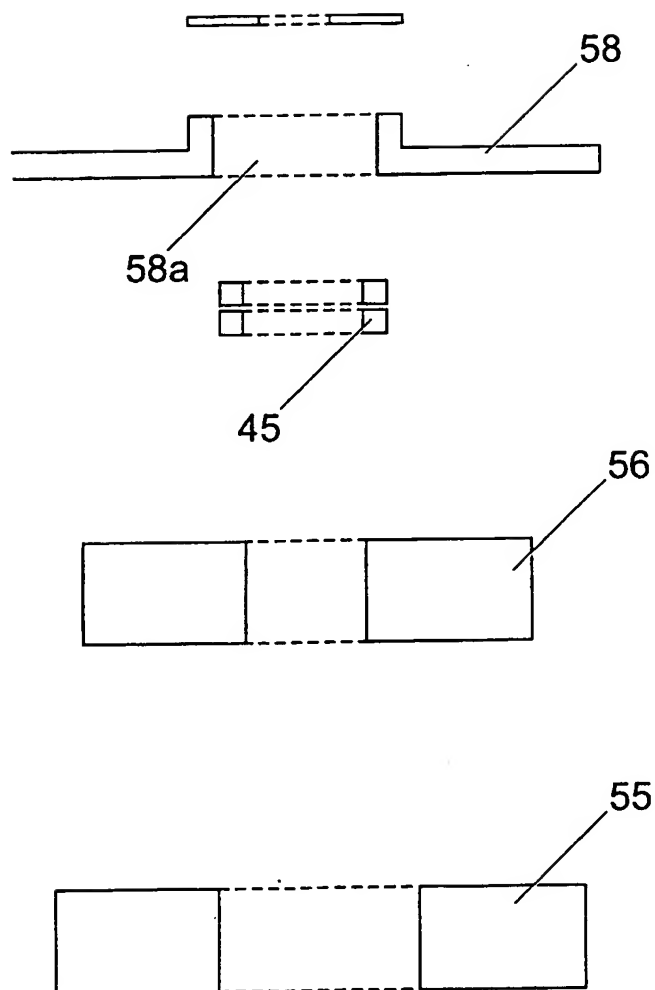
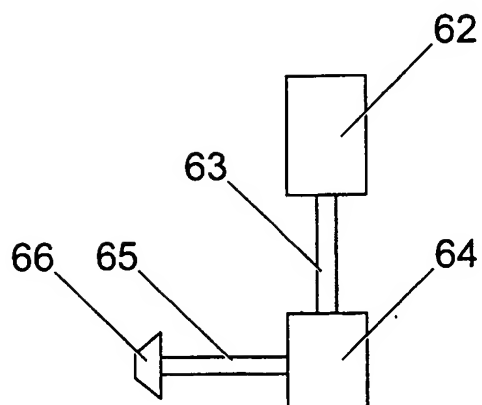


Fig. 8c

11 / 26

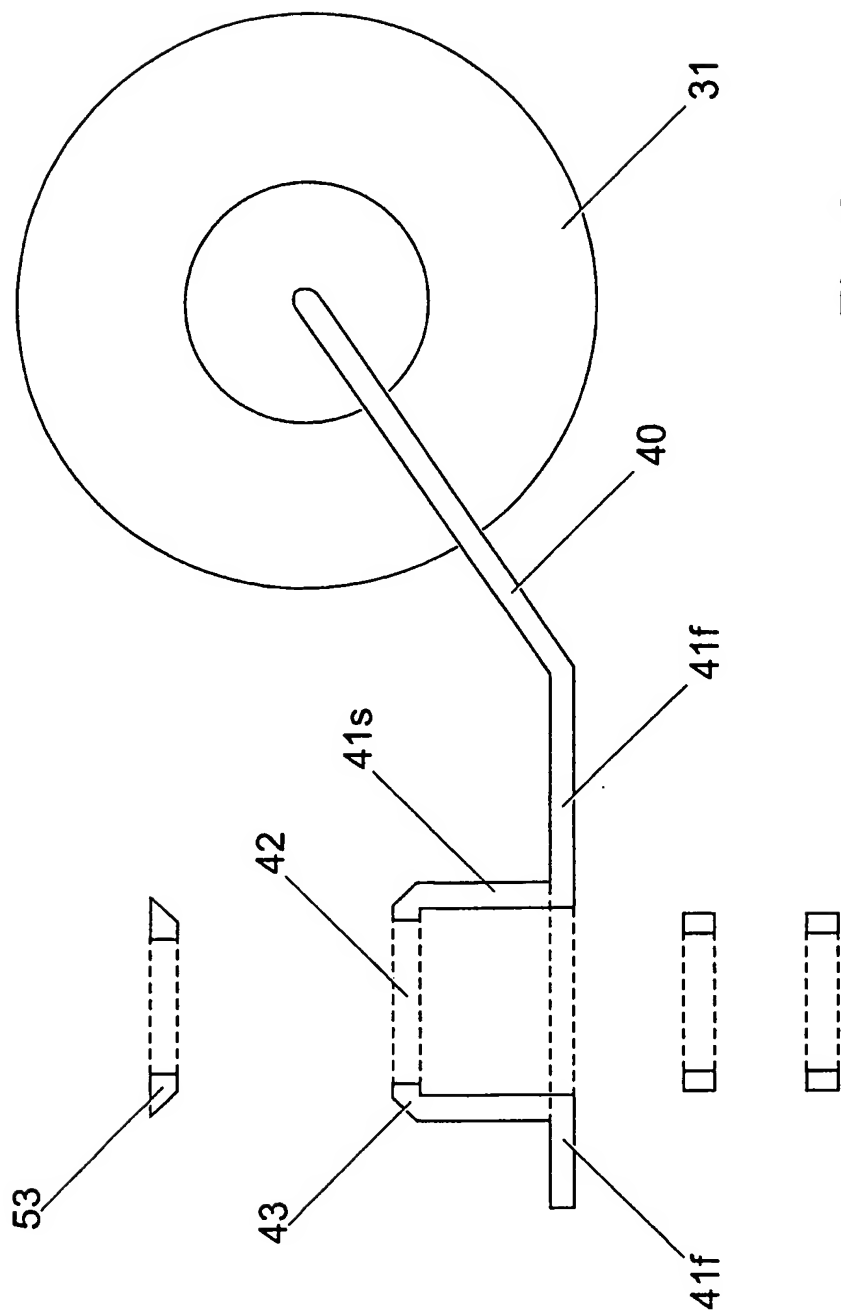
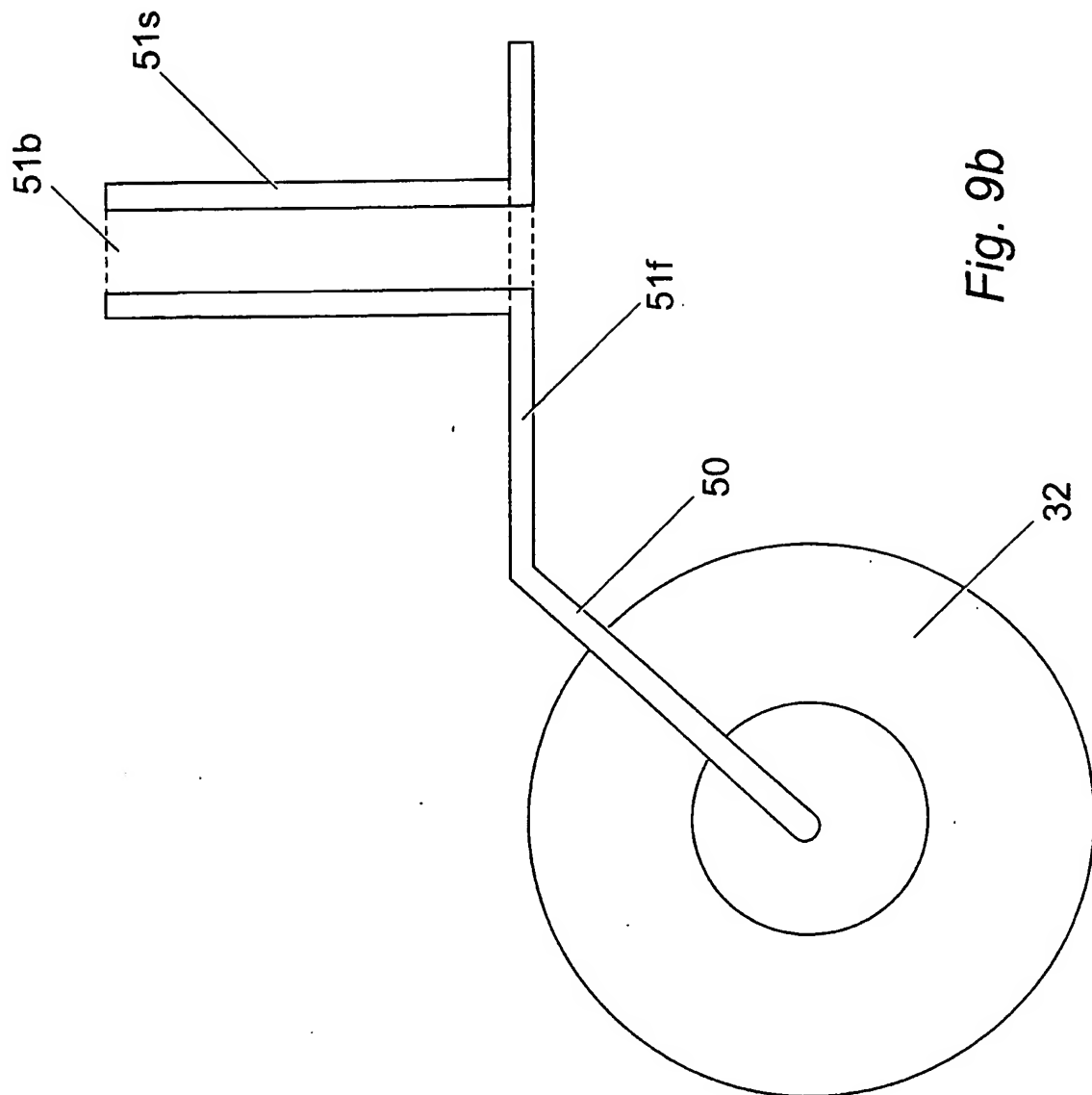
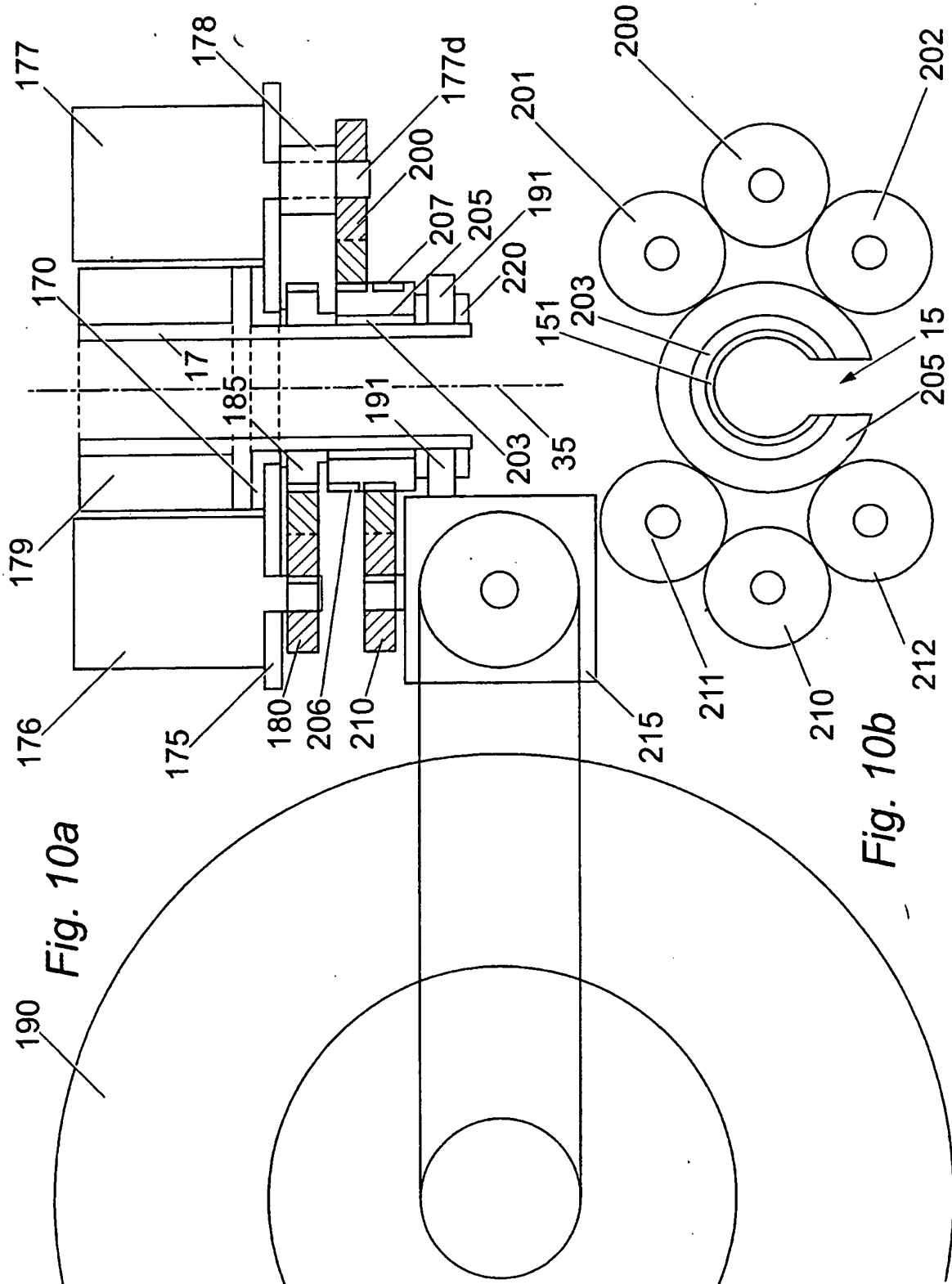


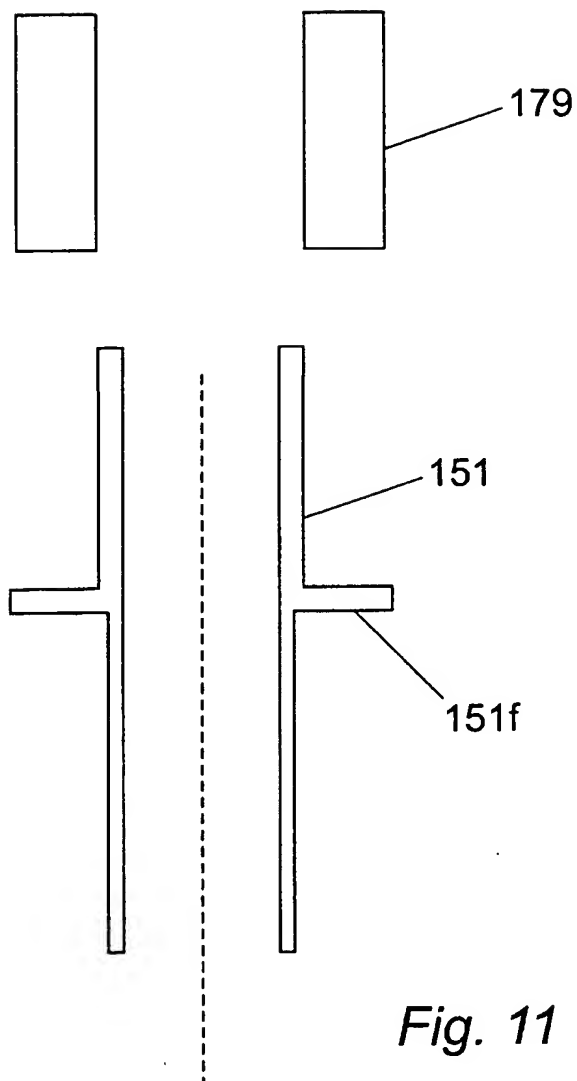
Fig. 9a

12 / 26



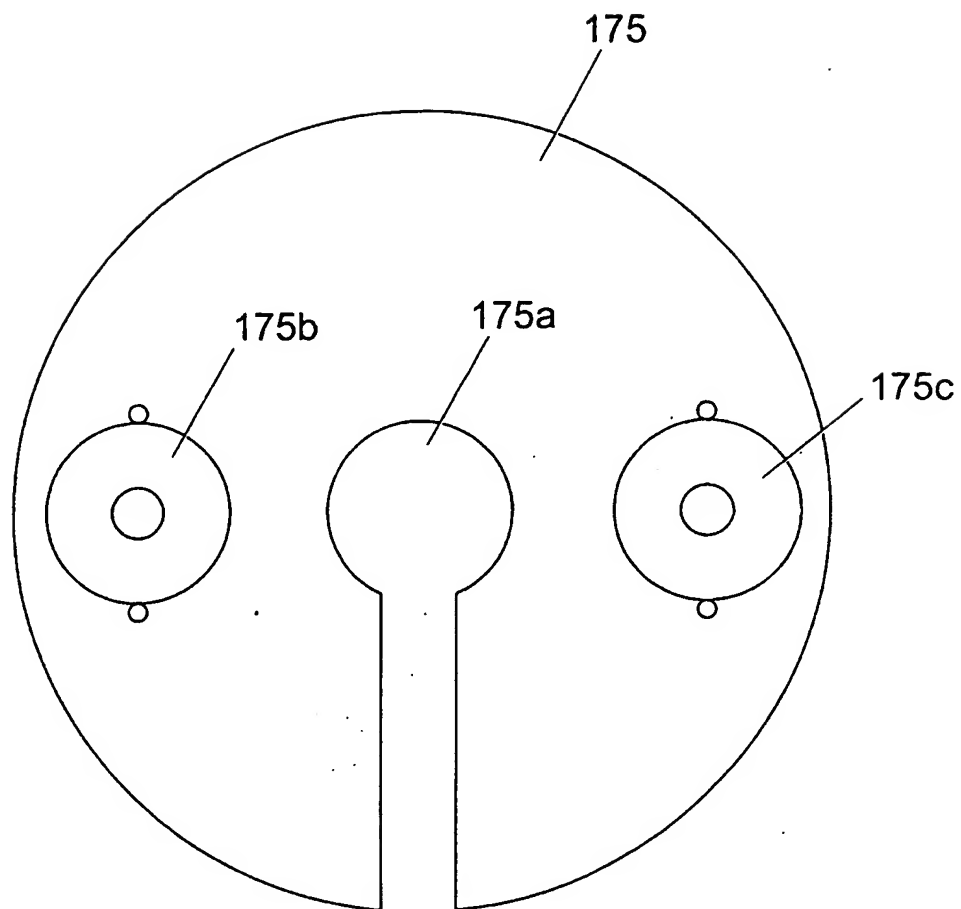


14 / 26



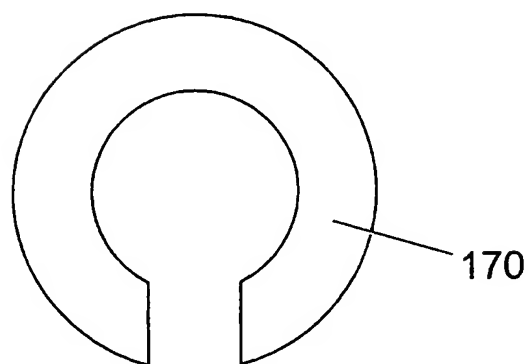
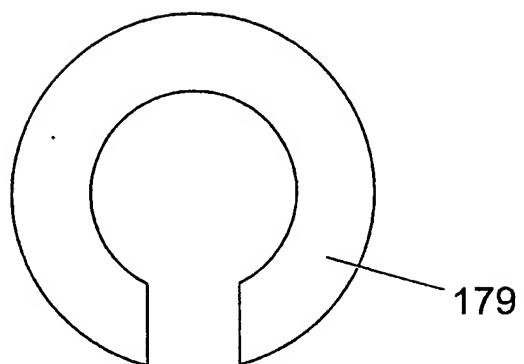
*Fig. 11*

15 / 26



*Fig. 12*

16 / 26



*Fig. 13*

17 / 26

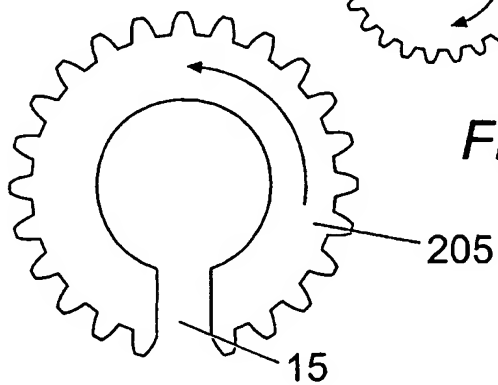
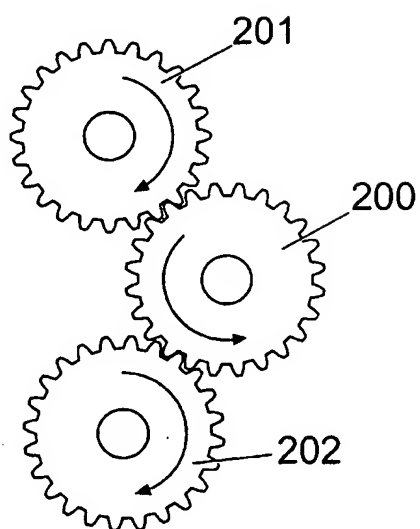
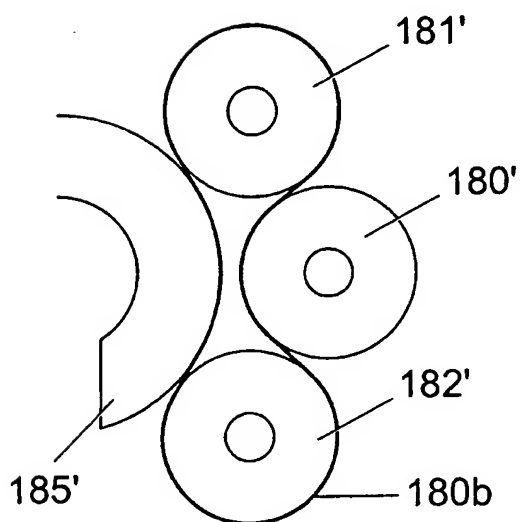
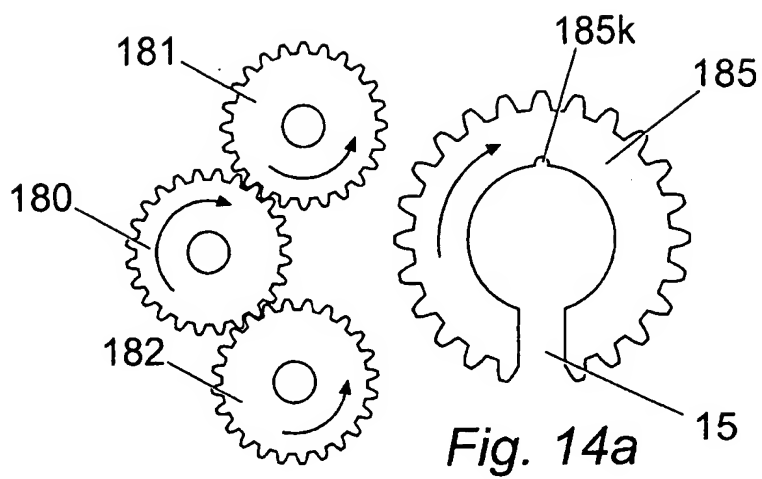
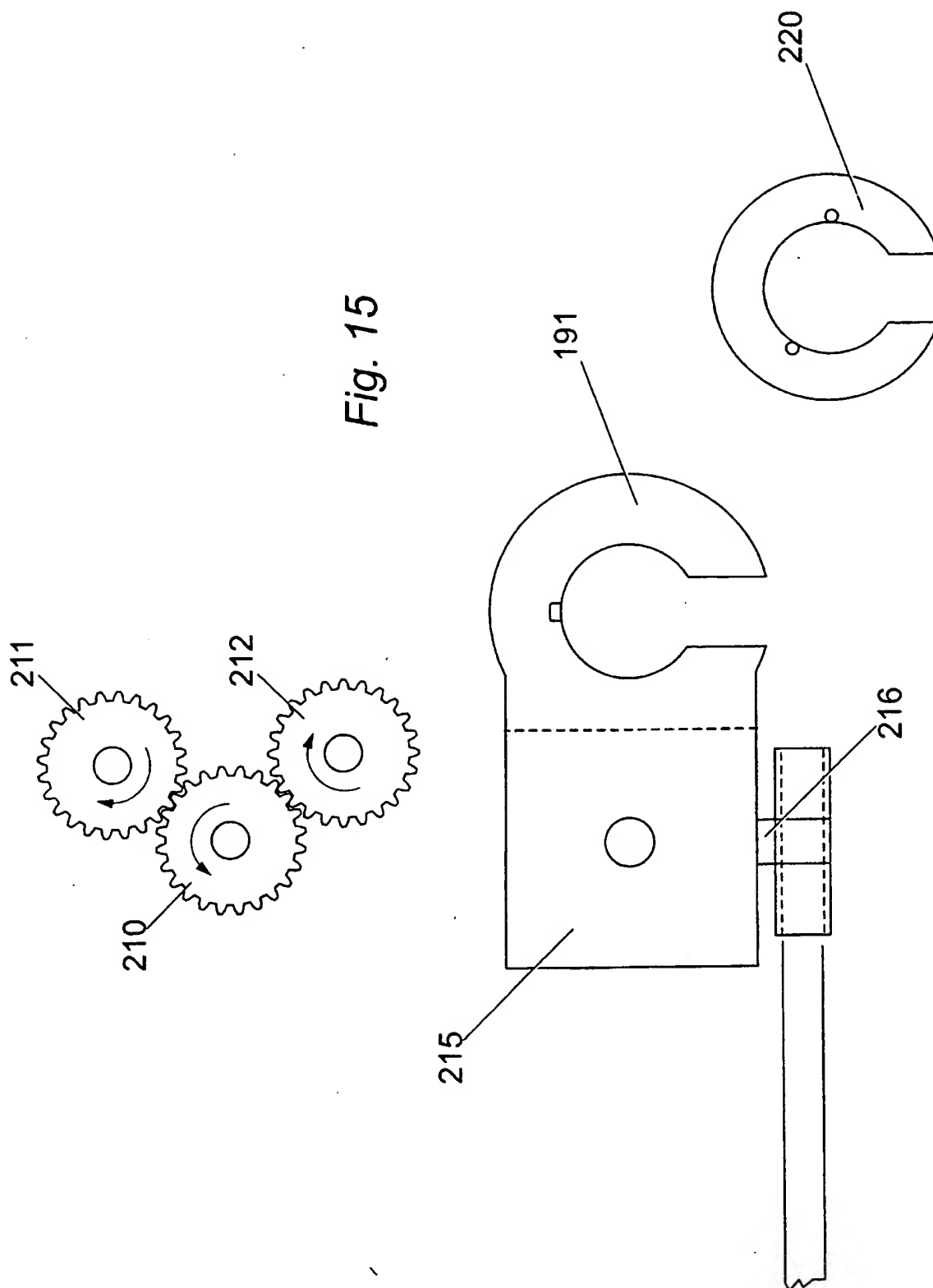
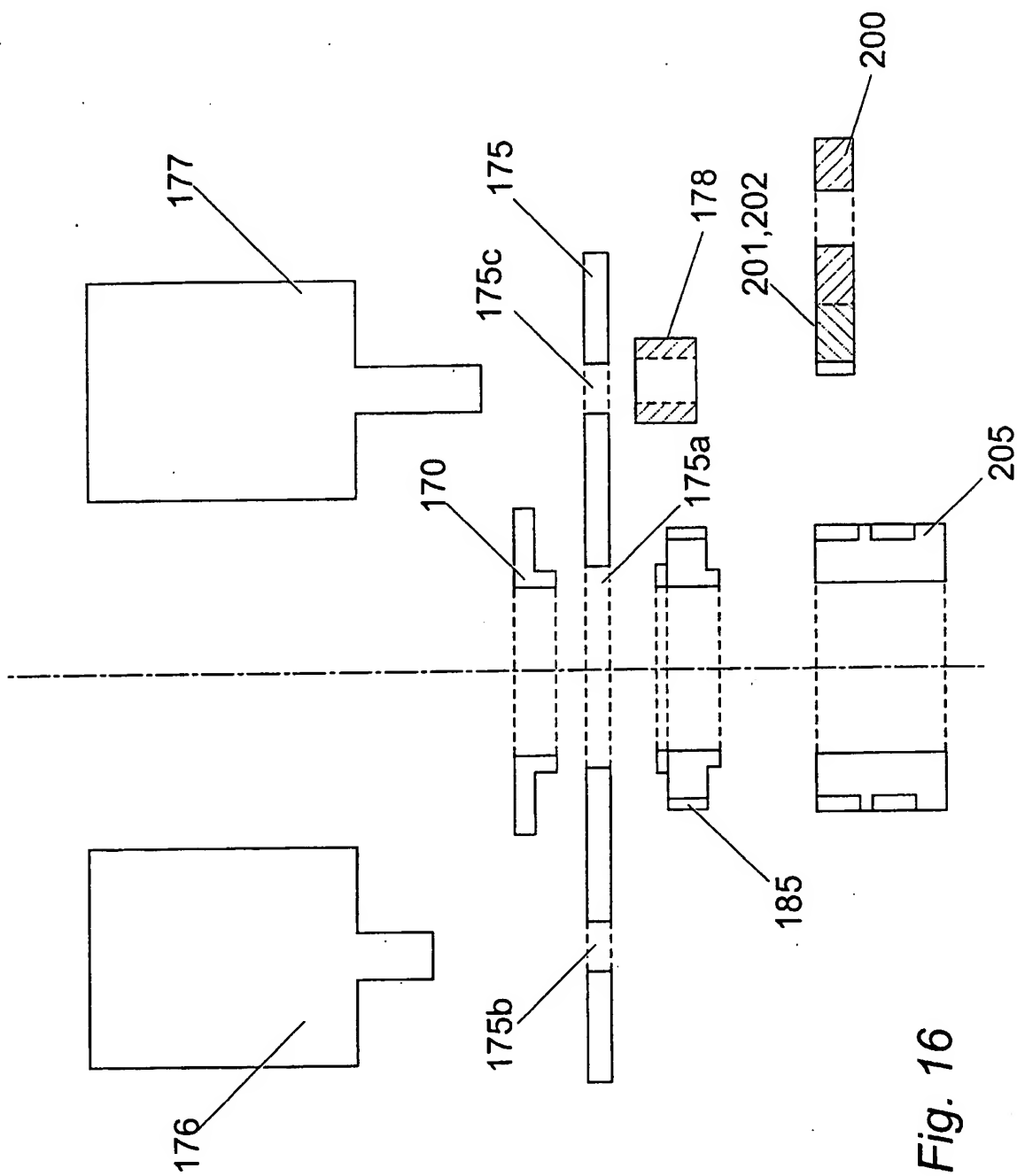
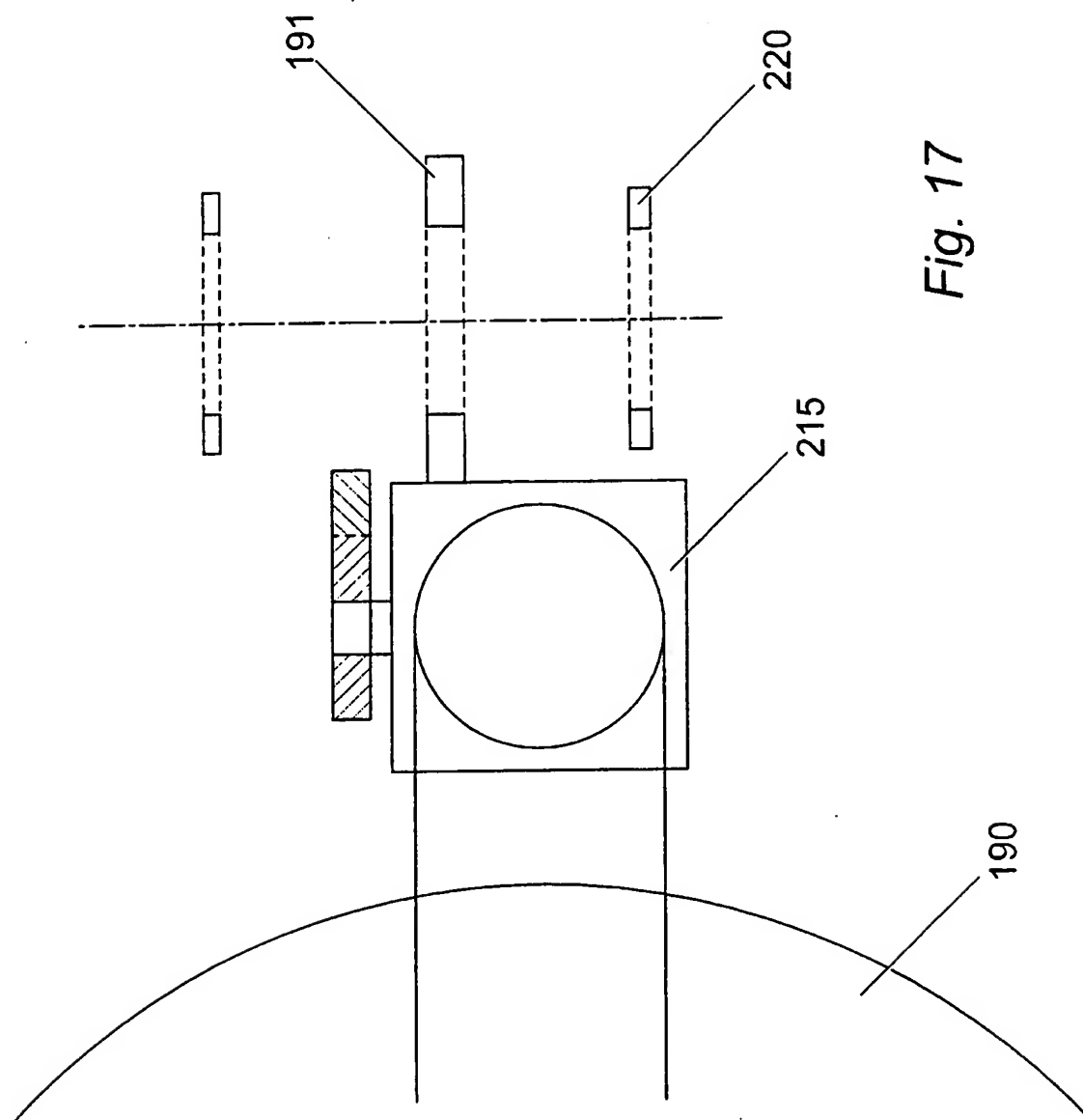




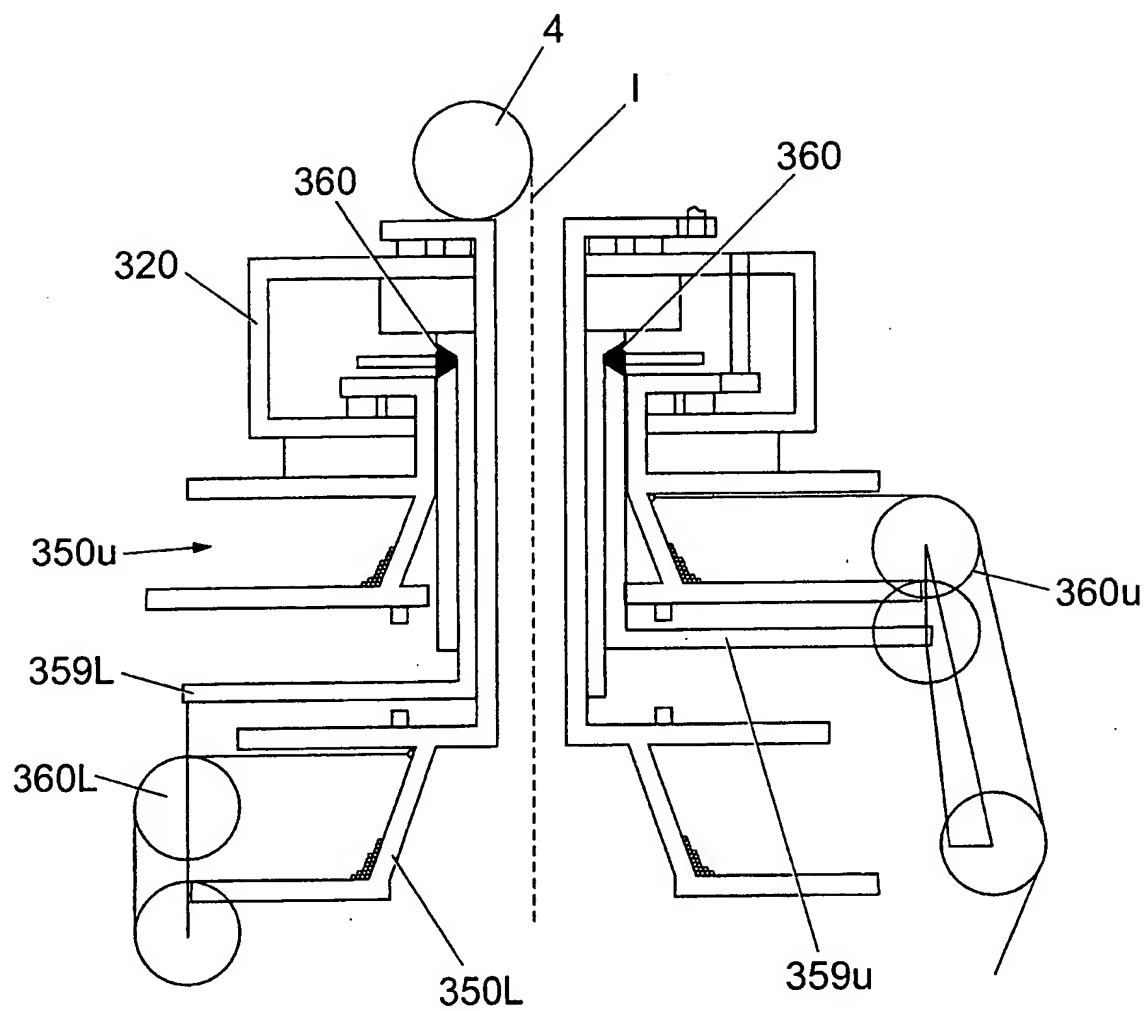
Fig. 15

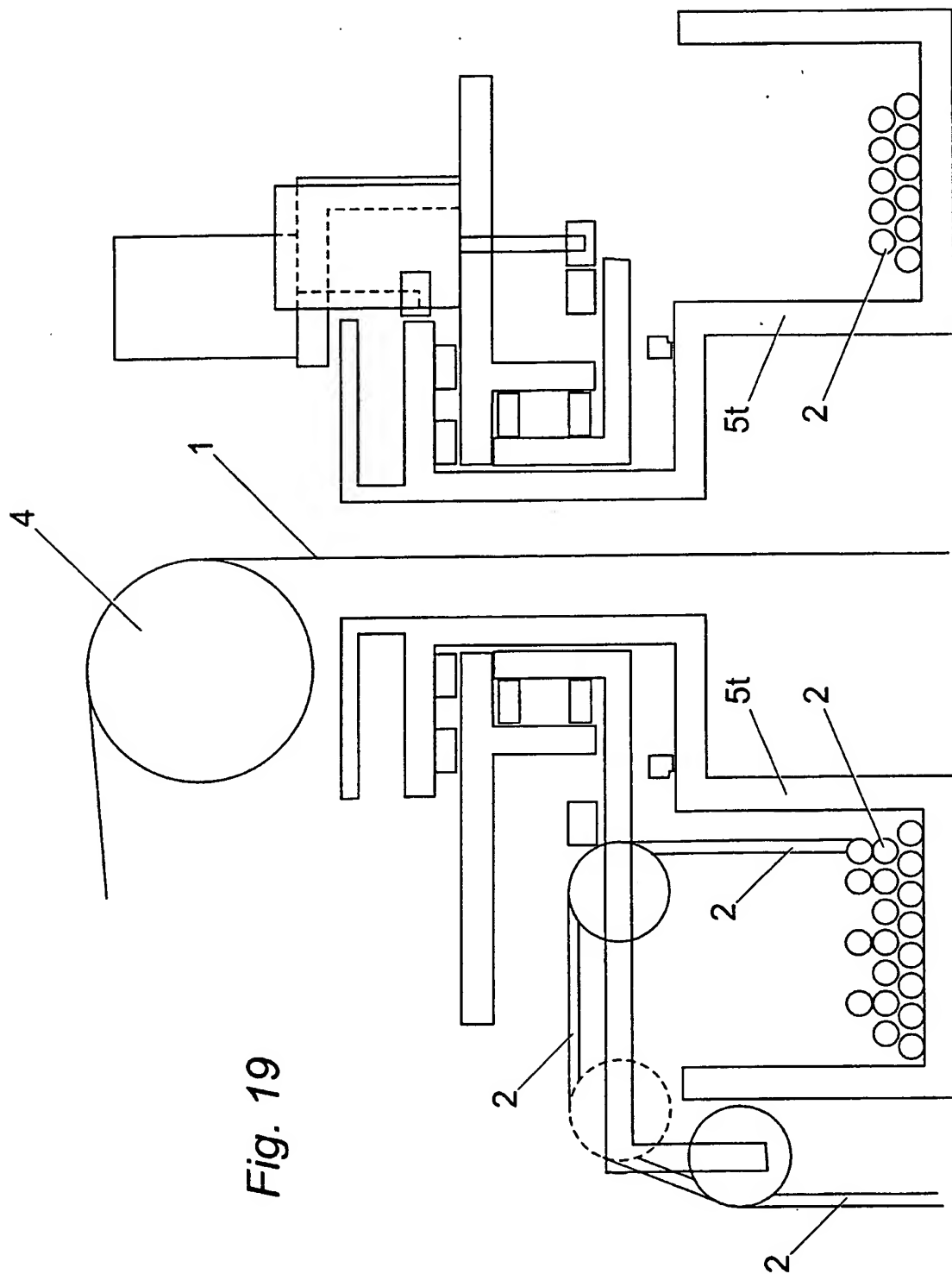


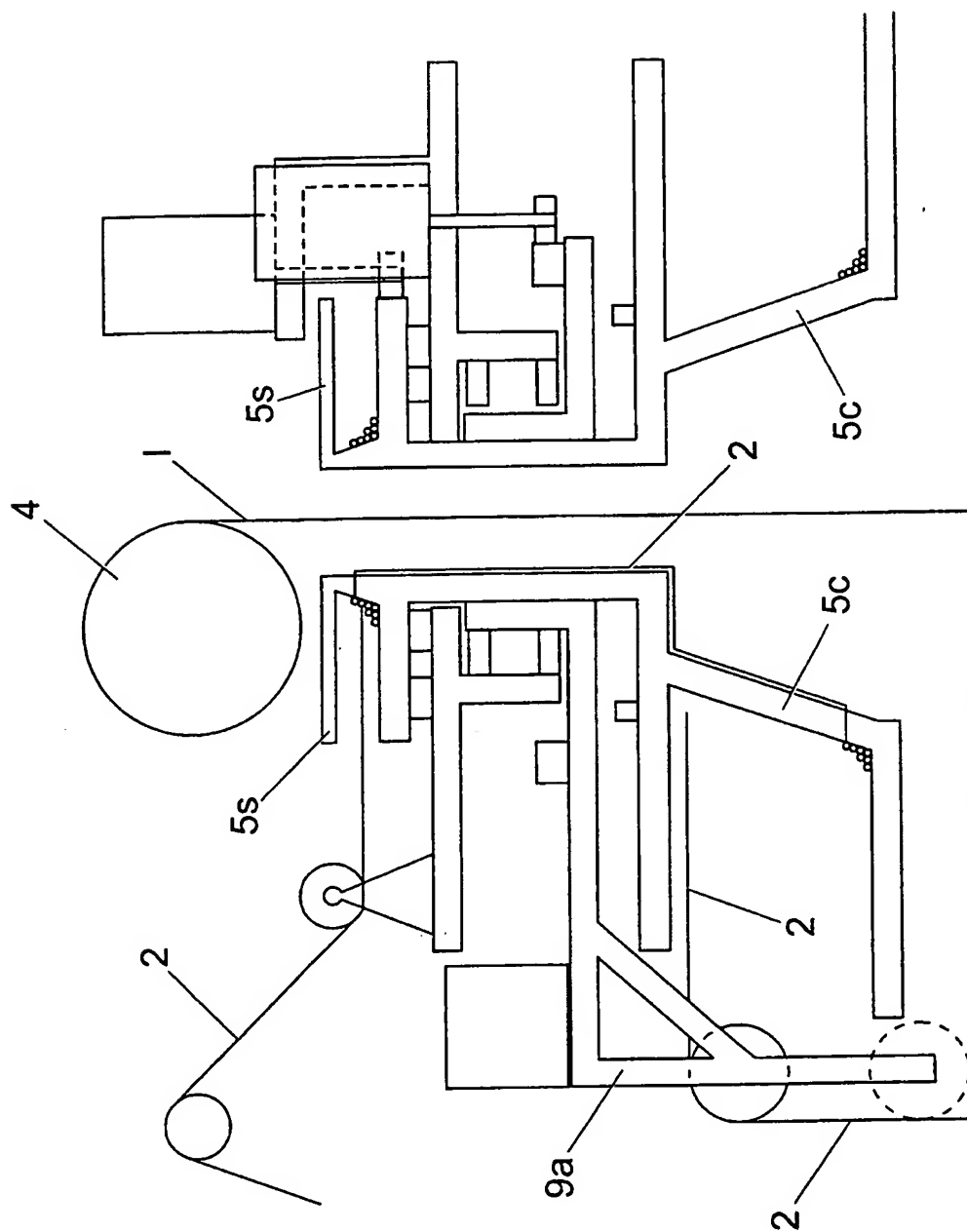


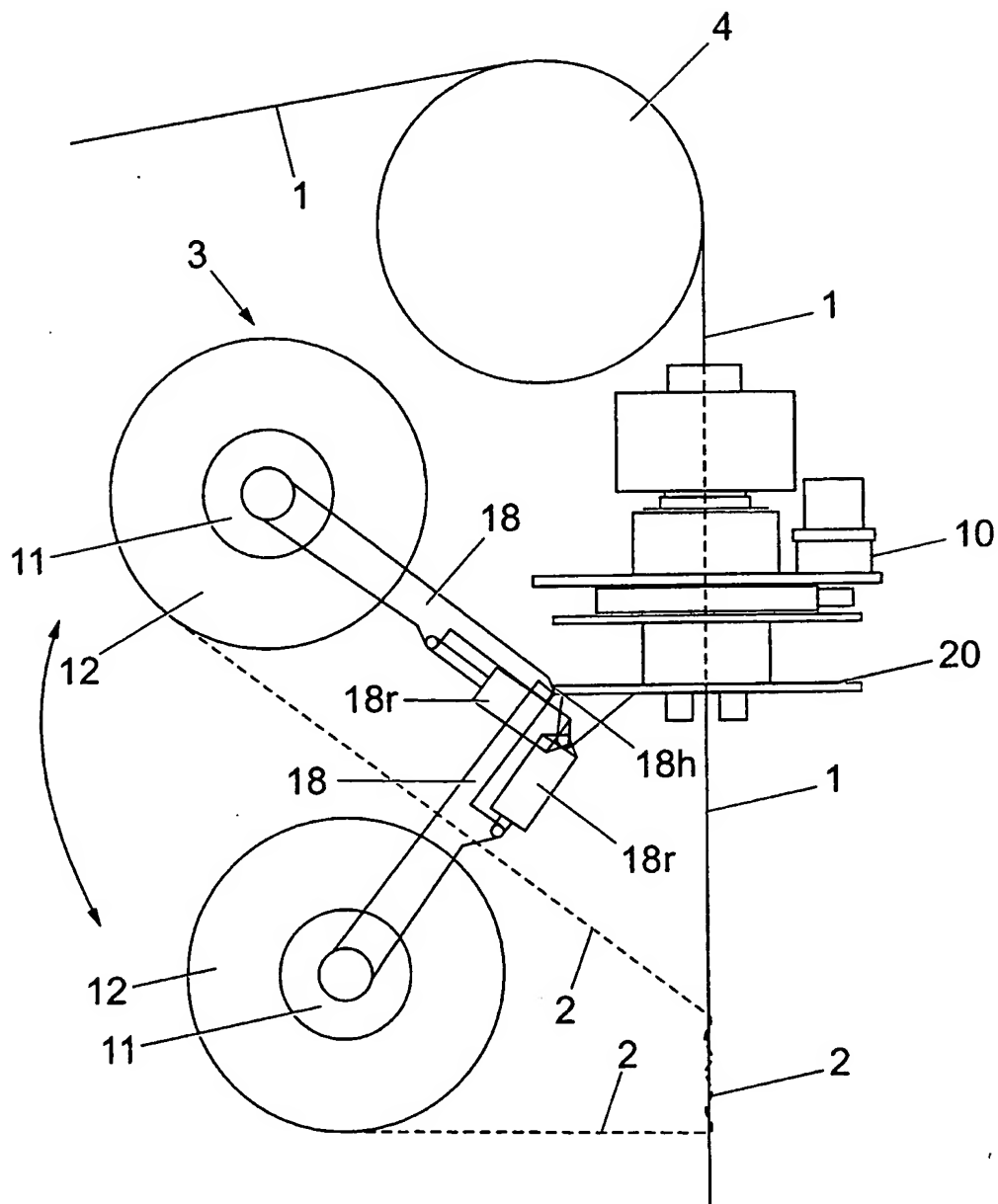


21 / 26

*Fig. 18*

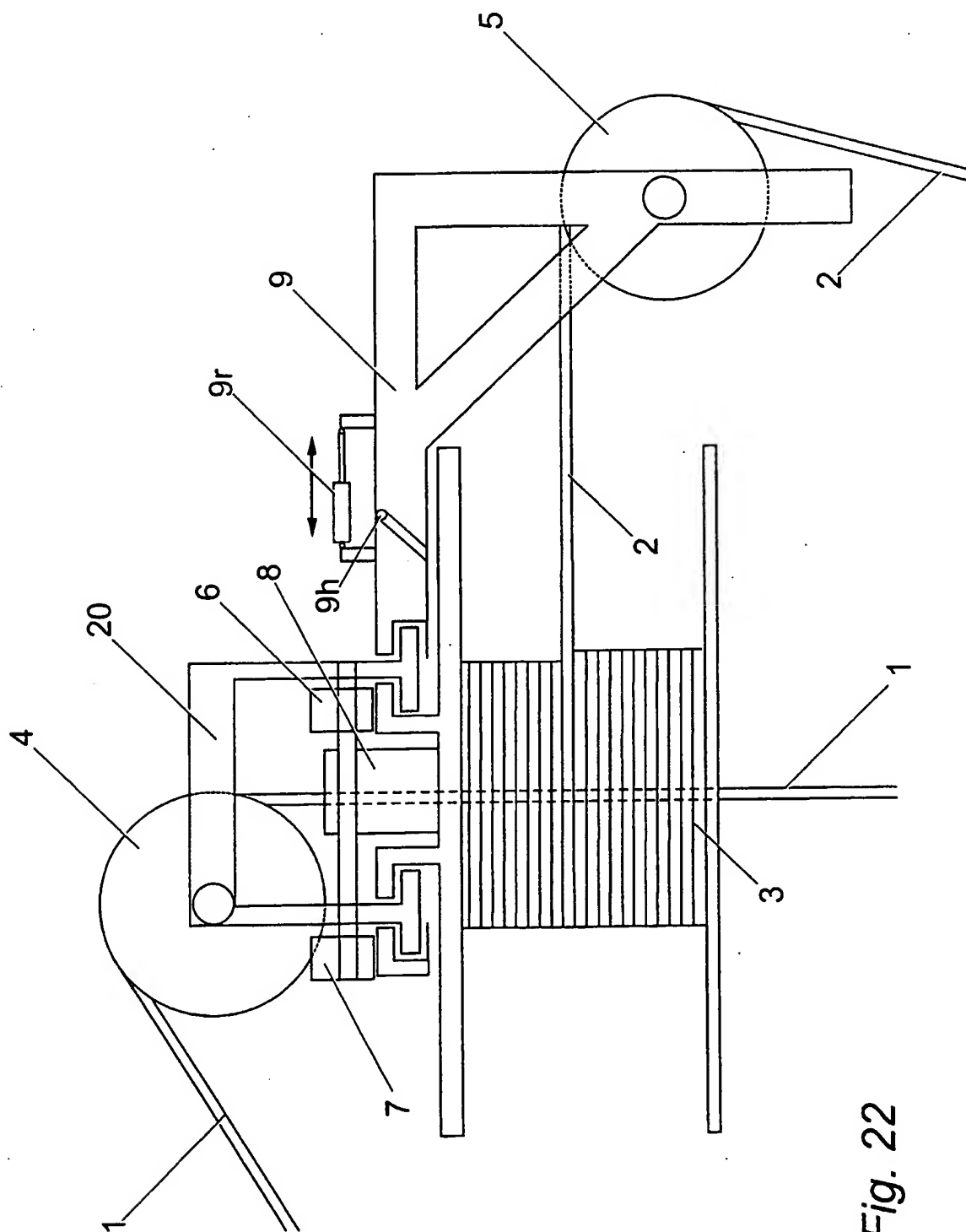






*Fig. 21*

25 / 26





26 / 26

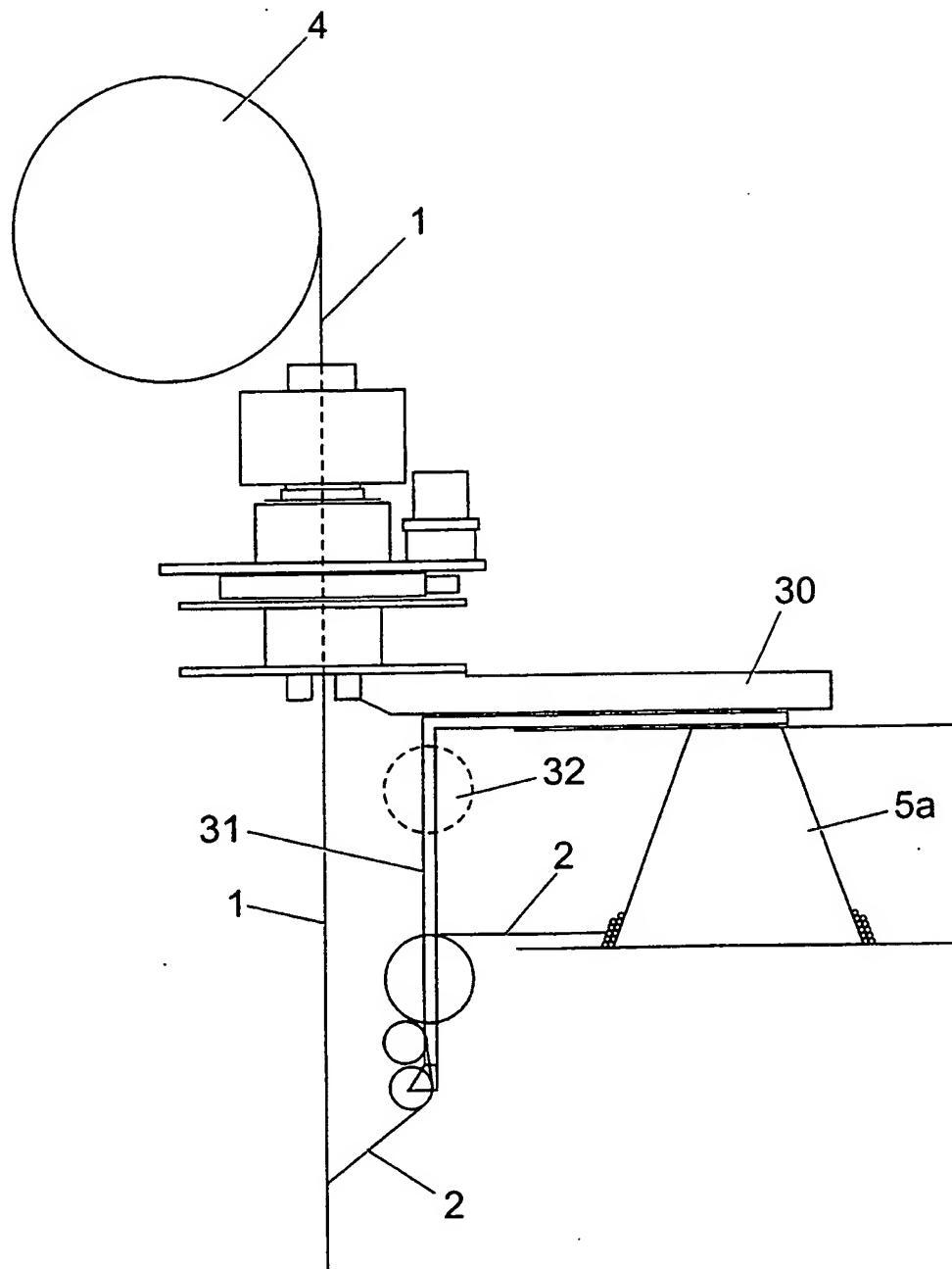


Fig. 23

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/00978

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 B66C13/14

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 B66C H01B G02B H02G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 96 22935 A (DEEP WATER RECOVERY & EXPLORAT ;CRAWFORD ALEXANDER CHARLES (GB)) 1 August 1996 (1996-08-01) cited in the application the whole document	1-10, 18
Y		19
A		13, 21, 22
Y	US 4 250 351 A (BRIDGES ROBERT M) 10 February 1981 (1981-02-10) abstract	19
A	column 1, line 5 -column 2, line 17 figure 1	11

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

7 July 2000

Date of mailing of the international search report

14/07/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax: (+31-70) 340-3016

Authorized officer

Sheppard, B

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 00/00978

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9622935 A	01-08-1996	AU 691070 B	07-05-1998
		AU 4456796 A	14-08-1996
		DE 69603451 D	02-09-1999
		DE 69603451 T	04-05-2000
		EP 0805776 A	12-11-1997
		ES 2137656 T	16-12-1999
		GR 3031615 T	31-01-2000
		JP 10512838 T	08-12-1998
		NZ 298874 A	28-01-1999
US 4250351 A	10-02-1981	DE 3028113 A	26-02-1981
		GB 2056157 A,B	11-03-1981
		JP 1486221 C	14-03-1989
		JP 56028411 A	20-03-1981
		JP 63033243 B	05-07-1988

**This Page is Inserted by IFW Indexing and Scanning  
Operations and is not part of the Official Record**

**BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☒ BLACK BORDERS
- ☒ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☒ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☒ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☐ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: \_\_\_\_\_

**IMAGES ARE BEST AVAILABLE COPY.**

**As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.**